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EFFECTS OF INQUIRY TRAINING IN PHYSICAL SCIENCE ON CREATIVITY AND COGNITIVE STYLES OF ELEMENTARY SCHOOL CHILDREN.
BY- SCOTT, NORVAL C., JR. SIGEL, I.E.
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AN INQUIRY (SPECIFIC DISCOVERY) APPROACH TO LEARNING WAS SUBJECTED TO A RIGOROUS TEST AND EVALUATION PROGRAM, INVOLVING ELEMENTARY INSTRUCTION IN THE PHYSICAL SCIENCES. STUDENTS IN THE FOURTH, FIFTH, AND SIXTH GRADES SERVED AS SUBJECTS. EVALUATIVE CRITERIA WERE (1) SCIENCE CONCEPT ACHIEVEMENT, (2) DIVERGENT THINKING OR CREATIVITY, AND (3) COGNITIVE STYLES. IN ADDITION, EFFORTS WERE MADE TO DETECT SEX DIFFERENCES AND COGNITIVE DEVELOPMENTAL TRENDS. A MATCHED CONTROL GROUP OF STUDENTS TAUGHT BY CONVENTIONAL METHODS SERVED FOR COMPARISON. ONLY IN THE COGNITIVE STYLE TASKS DID THE INQUIRY APPROACH SHOW SIGNIFICANT EFFECTS ON CONCEPTUAL ACTIVITIES. THE INQUIRY PROCESS APPEARED GENERALLY TO ENCOURAGE AND DEVELOP AN EXPLORATORY ATTITUDE ON THE PART OF THE INDIVIDUAL LEARNER WHICH LED HIM BEYOND BASIC, OVERT PERCEPTION. INQUIRY GROUPS IN GRADE 5 ACHIEVED SCIENCE CONCEPTS BETTER THAN CHILDREN TAUGHT BY CONVENTIONAL MEANS, BUT THE TWO GROUPS IN OTHER GRADES SHOWED LITTLE DIFFERENCE IN SCIENCE CONCEPT ACHIEVEMENT. LITTLE DIFFERENCE IN CREATIVE THINKING WAS EVIDENCED BUT THE INQUIRY CHILDREN WERE MORE FLEXIBLE IN THEIR CLASSIFICATION BEHAVIOR AND MORE ATTENTIVE TO DETAIL IN PROBLEM SITUATIONS. OVERALL IN THE THREE GRADES BOYS SHOWED GREATER VARIABILITY THAN GIRLS IN THEIR ATTENTION TO DETAIL AND USE OF CLASSIFYING LABELS. (JH)

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Norval C. Scott Jr. and I. E. Sigel

The Merrill-Palmer Institute
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CHAPTER I

INTRODUCTION

The recent revival of interest in cognitive development has stimulated considerable research into all processes of intellectual development. The significance of this revival is in its potential value for the educational process, for now we are on the threshold of a new era; the rapprochement between research in child development and curriculum development, especially at the elementary school level.

Recent investigations in child development have identified a number of cognitive variables which play a crucial role in the child's learning. Among these have been those cognitive functions called cognitive style, referring to the consistency with which children orient themselves and categorize classes of material (Kagan, Moss, and Sigel, 1963). The basic assumption underlying such a concept is that the child develops, through experience yet to be identified, particular preferences for classification of social and non social items in his environment. Such classificatory behavior is necessitated by the individual's need to organize the polydimensional world in which he lives. The child develops his own categories after learning how and what items belong together on the basis of some perceived similarity. These similarities become the criteria by which class concepts can be established. Further, the child develops behaviors relevant to these categories and in this way is able to respond to a variety of items in a precise and effective way. The individual does not need to learn anew how to react to each unfamiliar item he sees. Having a general knowledge of the class "automobile", we do not have to learn how to respond to each new instance in which we come into contact with autos.

In the course of development, we learn what are the meaningful criteria by which to classify items into an already established class. We know the relevant criteria for the class "automobile" and hence we have no difficulty in classifying a car we have never seen before into an already existing class.

There is however no one class to which every object or event belongs. Rather items can be placed in any one of a number of classes depending on what criterion or criteria are selected. This is possible because every object and every event has multiple attributes. The "auto" can be classified with other cars because of their common class membership in the class "automobile." The awareness that objects are not absolutely tied to any one class is a crucial matter, since it reflects the individual's flexibility and sense of the complexity of items. This type of realization is critical in order to solve problems. A number of studies, especially those of N. R. F. Maier (1930, 1931,1940), demonstrated that the ability to reclassify an item from its commonly associated function into alternate functions is a considerable asset in solving problems.

The orientation the individual has to the world of objects in terms of his awareness of their complexity and the impact such awareness has on his processing of new information is reflected in the inter-relationship of cognitive style and acquisition of science concepts in a discovery type teaching context.

Styles of categorization have been identified as stable preferences manifested by children of all ages. Three dimensions of style have been defined, (1) descriptive, the classification of objects (animate and inanimate) on the basis of their manifest observable characteristics;

(2) relational-contextual, organizing objects on the basis of their interdependence in a given context; and (3) classifications based on inferences made about the nature of materials, when each instance of a group represents the class.

Since these types of styles are indications of preferences individuals show in their mode of organization, there is no absolute way to classify; each of these approaches is correct--expressing the employment of particular criteria as a basis of perceiving similarity.

Conceivably any one of these approaches can be used when an individual is faced with the task of classification. Most of the individuals involved in our study do show, as we shall see, ability to use one or more of these approaches. The ability notwithstanding, there are tendencies for preferential modes of operating.

With these as our givens, how do they relate to science concept achievement? Let us think for the moment of the relevance of these characteristics and the approach to a science problem. To solve a problem in science it is necessary to be able to identify relevant details, use inferences to explain the change or the reasons for particular occurrences, and understand relationships. Each of these is, in effect, reflective of a particular style. We know, however, that individuals have stylistic preferences, and have tendencies to employ a particular approach in attacking a problem. If one has a predisposition to deal with the manifest, and is reluctant, for whatever reason, to deal with relationships or make inferences, some difficulty will be encountered in coming to grips with a problem.

Of course, these may not be of considerable import if the teacher presents the students with all essential information, reducing the need to define an approach to the problem. If, however, the way of teaching is one employing discovery-type teaching, then the styles of categorization become more salient. Now the teacher encourages the child to discover his own solutions through inquiry and exploration. Here the child's preferential mode for approaching problems and acquiring information could play a more pervasive role. Depending on his style, he may shut out certain aspects of information. If he has, for example, a tendency to deal with the manifest, then he may only attend to certain classes of information without bothering to obtain knowledge of the non-manifest aspects and consequently fail to solve the problem. Particular styles may in effect be deleterious to profiting from such a learning opportunity.

On the other hand, exposure to particular kinds of discovery-type learning situations seems to have an influence on the styles the children employ. The structure of Inquiry is one in which the teacher plays a minimal role in directly stimulating the child intellectually. The teacher in addition provides the child with the opportunity to take the lead in processing data from his own observations. She responds to the child in such a way as to enable him to reach a stage where he is able to reject his own irrelevant inquiries. This may well contribute to the child's transformation of his approach from a fixed consistent one to a flexible relative one, depending on the problem and the level of background information already attained by the child.

The emphasis in our Inquiry teaching was on the processing of data along the lines of causality, since science concepts seemed to be a web of cause-effect relationships. The focus on causality as a central theme differentiates our teaching strategy from that of J. R. Suchman (1962), the originator of the type of Inquiry teaching employed in this project.

The elementary school children in the study were introduced to the Inquiry teaching program in their science classes. A closely structured curriculum was devised employing such basic concepts as balance of forces and conservation of volume. Instances of these concepts were presented in the form of scientific events and the child was to discover the cause-effect principles involved.

Coming into the classroom with certain stylistic preferences, the child may find his way of approaching the problem inadequate. To succeed, he has to alter his way of working. Such demands may produce cognitive restructuring--a reorganization of approach in the face of persistent failure to solve the problem. In this way, cognitive style may be altered in the Inquiry experience.

Inquiry and cognitive style then are interdependent, the degree to which this is actually so is an empirical question--and that is the basic query to which the remainder of this report will be addressed.

CHAPTER II

BACKGROUND OF THE STUDY

Suchman's effort to improve the curriculum through inquiry approaches to learning, provided a searching, discovery-oriented method by which the student could actively control the intake of data in order to solve problems in the area of the physical sciences. Suchman held that the greater the student's control of the information process, the more likely he would become an autonomous learner. In order to achieve this, the student would need motivation to develop, or modify, his own conceptual schema, and in this way develop a more stable and functional set of cognitive operations.

Suchman (1962, p. 7) delineated four areas of concern essential to the stimulation of this searching behavior:

> (a) a domain in which to operate - a place to search in, (b) freedom to move within this domain, to decide in what direction to move at each choice-point, (c) a "set" to guide the selective procedures, to enable one to differentiate and evaluate data in terms of his goals, and (d) an overall system or plan (it may not be a conscious one) to guide the sequence of search operations.

Points a and b are chiefly concerned with mobility of thought. To encourage this mobility, Suchman developed an idea for encouraging the student to ask the teacher questions answerable by a yes or a no. The teacher's role is one of anticipating the student's potential lines of thought, and following his lead rather than guiding him. With this method it became apparent that encouragement of searching behavior could be accomplished in the classroom. Students seemed to enjoy their new found opportunity to explore and to discover through question-asking. Searching and discovery, however, are but two phases of information investigation. There is also need to consider Suchman's points c and d, which are concerned with manipulation of data to maintain efficiency in the problem-solving process. To encourage the development of strategy in the pupil's mind, several techniques were devised to enable the child to process and integrate his newly discovered information.

This effort to place the learner in a so-called driver's seat definitely affected the child's strategy in problem-solving situations. Suchman (1962) found that in the groups using Inquiry, the children's conceptual attainment in physical science material was equal to or better than the conventionally taught groups, even though there was greater emphasis in the Control situation on content. The Inquiry groups were much more fluent in question-asking than the Controls and asked a larger number of analytical questions, reflecting intensive searching and probing in their problem-solving behavior. An intriguing hypothesis suggested itself at this point: Was it possible that the Inquiry children had assumed a searching behavior that transcended guesswork in favor of a more sophisticated problem-solving strategy? Suchman, due to the limitations of his study, was not in position to consider what remained an unanswered question: Does this particular Inquiry methodology effectively change the problem-solving strategy and attendant cognitive processes of children? If so, how?

Although we have no definitive answers to this question, we have some clues indicating relationships between Inquiry and cognitive processes in a study by Scott (1962). Using subjects in grades 5, 6, and 7 trained in an Inquiry program, he found that inductive reasoning and styles of categorization were related to the science concept achievement level of these children. In the case of inductive reasoning, this relationship held for ten-year old children whereas styles of categorization held for only the eleven-year olds. This unexpected finding showed that age was an important factor attenuating all relationships with science concept achievement in Inquiry. Although he had no empirical verification that the Inquiry process was connected with these relationships, his use of styles of categorization as one way of assessing the consequences of the Inquiry technique is germain. Scott's report fell short of assessing the effect of Inquiry on the intellective processes of children, since he had no control groups of children taught conventionally. Such a procedure would have highlighted similarities and differences between the strategies of children taught by the two methods. The question of the effect of Inquiry on Cognitive Style also remained to be answered. The next step appeared to be related to the need for comparing the influence of Inquiry on the cognitive functions of children.

The lack of empirical evidence regarding the efficacy of the Inquiry method has led many educators to be skeptical of the soundness of this approach. Some doubt the wisdom of teaching science concepts in such an open-structured manner. They claim that laboratory-type experience where the child brings all of his senses into play on his science activities, rather than the purely intellective approach of Inquiry, holds the edge in the achievement of concepts, even though Suchman, as mentioned previously, has reported that children studying science using the Inquiry approach had gains in substantive knowledge comparable to those of children taught in a more traditional way. A second criticism is that Inquiry is perhaps appropriate only for children from middle income groups. It is true that Suchman used children predominantly from middle income groups for his investigation and most kinds of teaching methods seem to "work" with these children. Whether the Inquiry approach is applicable to lower class children is another issue since such children reportedly do not react eagerly and competently to verbally oriented activities, and Inquiry certainly is that.

In addition to social class as a factor to be considered, so is sex of the child. Thus far there has been some evidence that boys and girls are differently affected by teaching methods in science. The Inquiry program might have an adverse effect on boys who tend to be positively attracted to action-oriented programs but react somewhat negatively to teaching methods which stress verbal behavior. Deutsche (1943), testing the development of children's concepts of causal relationships among subjects in the eight-to-sixteen year age range, found where an actual science demonstration was made boys were consistently superior to girls. There existed then the possibility that sex differences might express themselves [illegible] the two learning situations.

A third factor that must be considered in assessing the impact of the Inquiry program is the age of the child. Previous studies by Scott (1962, 1964) and Suchman (1962) have demonstrated the practicality of employing Inquiry methods with children as young as grade five but have not indicated that pupils as low as the fourth grade can profit by such an approach. Whether the systematic approach observed in sixth grade children is due to their age level or to the Inquiry experience provides us with another angle for investigation and we will explore the effect of Inquiry on younger age groups.

In summary the Inquiry process is a provocative and unique vehicle for the teaching of concepts in the area of the physical sciences. This teaching method, although not focussing exclusively on content, raises a number of questions that need to be studied, among them the following:

1. Is the Inquiry procedure appropriate for use with fourth graders?
2. Does experience in an Inquiry program have an influence on Science Concept Achievement, Divergent Thinking (Creativity), and Styles of Categorization?
3. Does the Inquiry approach differentiate between the sexes in its effectiveness?
4. Is Inquiry an effective teaching method with children from a variety of socio-economic levels?

CHAPTER III

CONCEPTUAL FRAMEWORK AND DESIGN OF THE PROJECT

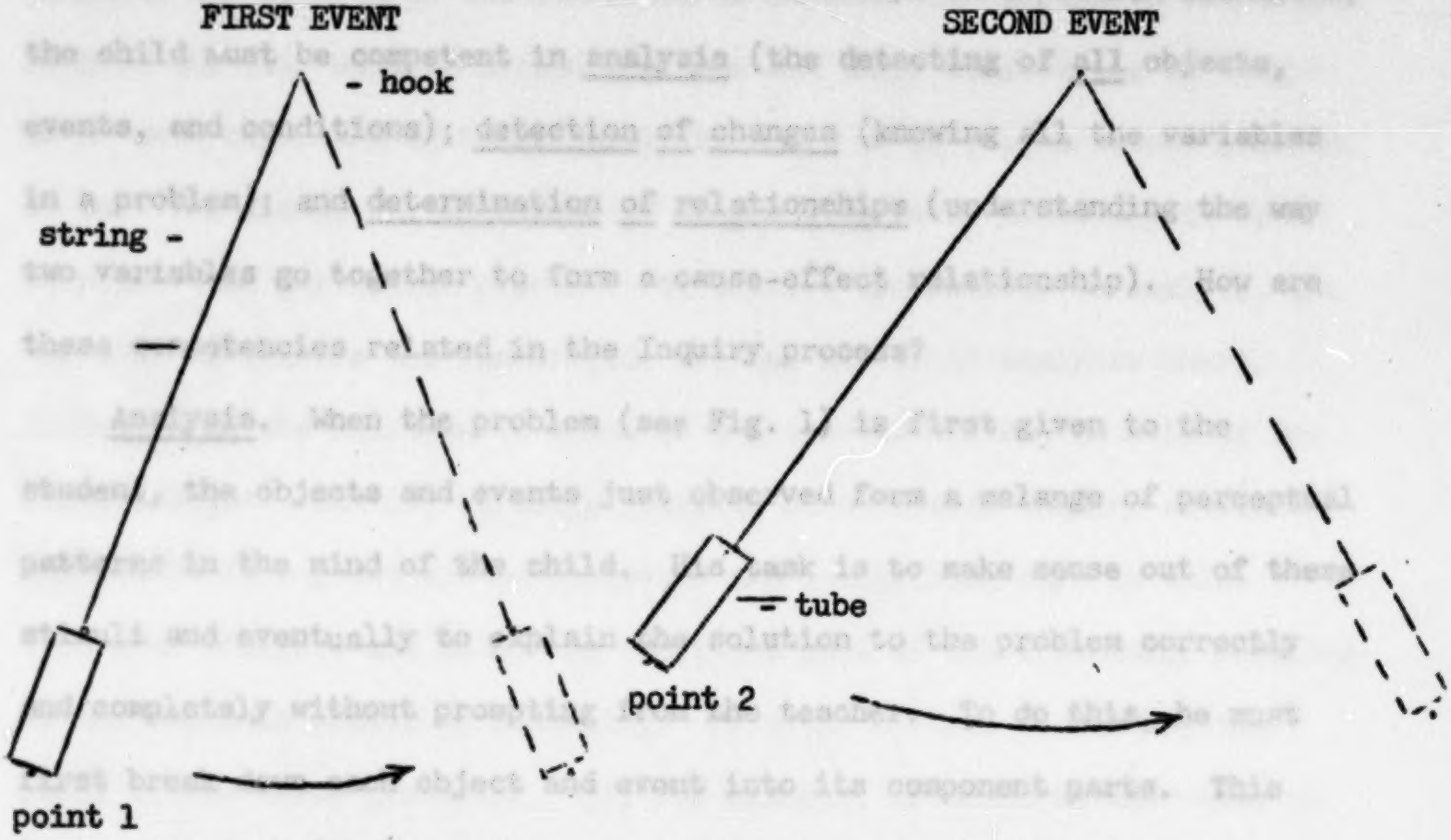
This project was designed essentially to assess the difference between two teaching methods, an inquiry approach and a conventional one. A second aim was to determine the degree to which these two teaching methods had differential effects as a function of the grade level involved. In this section we will describe in detail the conceptual framework and our procedures in order to accomplish these purposes.

Conceptual Framework of the Inquiry Process

Analysis of the Learning Strategy

As was indicated earlier, the focus in Inquiry was on the processing of data along the lines of causality since the science concepts seemed to be a web of cause-effect relationships. To illustrate the relationships of this strategy to causality within a science concept (or principle), we will analyze a problem situation of the kind used by classes involved in the Inquiry program. When a student is observing, for the first time, the cylindrical tube swinging on a string (shown in Fig. 1), he is hard put to explain why the number of swings changes when the tube is inverted. His first thought might be that something other than the inversion is causing the change. It is a matter of speculation whether the cause is simply the inversion of the tube, or whether it might be the arc of the swing, or the shifting of the center of weight. Any one, or all, of these variables could possibly be the significant cause of our observed effect. In order to make a satisfactory decision, the pupil must isolate the key variable. After this, he must go on to determine whether the relationship

PROBLEM: Why did the number of swings change?


FIRST EVENT
SECOND EVENT
- hook
string -
- tube
point 2
point 1

Attached to a string is a cardboard tube in which are four balls (see cut-away-view), the bottom one of which is steel. The first time, the tube is pulled back a short distance to point 1 and released to swing. The tube is inverted before the second event starts, then it is pulled back quite a distance to point 2 and released to swing.

CUT-AWAY-VIEW OF THE TUBE

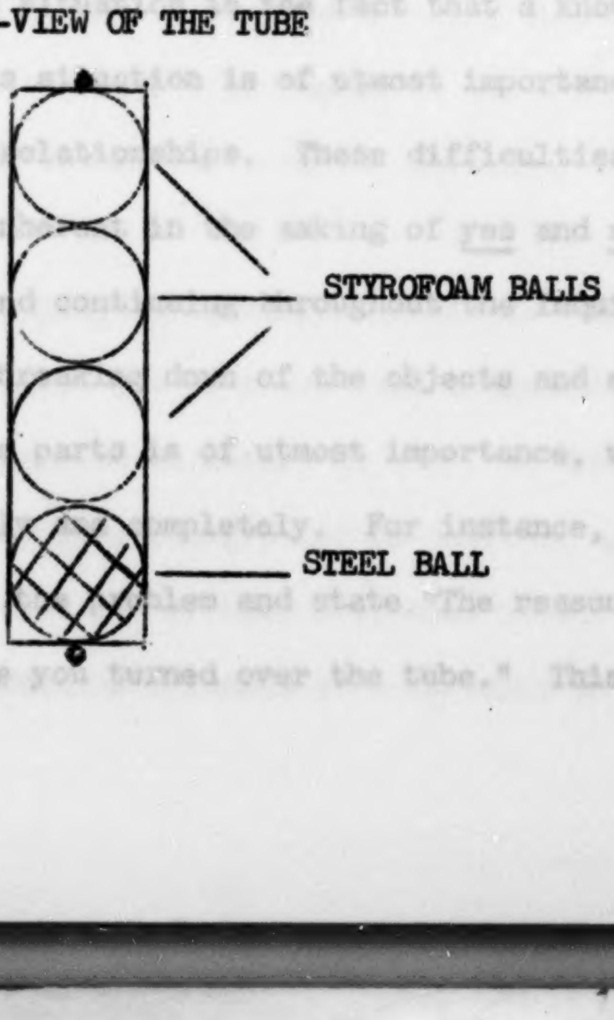

STYROFOAM BALLS
STEEL BALL

FIG. 1--Sample Inquiry Problem

between the variable and the observed effect was a direct or an inverse one. To understand the cause-effect relationships in a problem situation, the child must be competent in analysis (the detecting of all objects, events, and conditions); detection of changes (knowing all the variables in a problem); and determination of relationships (understanding the way two variables go together to form a cause-effect relationship). How are these competencies related in the Inquiry process?

Analysis. When the problem (see Fig. 1) is first given to the student, the objects and events just observed form a melange of perceptual patterns in the mind of the child. His task is to make sense out of these stimuli and eventually to explain the solution to the problem correctly and completely without prompting from the teacher. To do this, he must first break down each object and event into its component parts. This is no easy task for the child, especially when unfamiliar material is being used. Added to these difficulties is the fact that some persons (especially younger ones) have a tendency to see things globally, oft-times ignoring such details as the length of the string or the inversion of the tube. Confounding the analysis situation is the fact that a knowledge of the invisible objects in this situation is of utmost importance in understanding the cause-effect relationships. These difficulties are not solved by any natural process inherent in the asking of yes and no questions. In the beginning, and continuing throughout the Inquiry sessions, it is found that the breaking down of the objects and events into their visible and invisible parts is of utmost importance, when a problem is to be solved correctly and completely. For instance, a child might say that he could explain the problem and state "The reason the pendulum swung faster is because you turned over the tube." This is correct, but far from complete. What is missing from the child's knowledge of the problem is the awareness of objects not visible to the eye, such as the four spheres inside the tube and their differences in weight. If he were cognizant of these items, he would be in a much better position to spot the change in the center of weight that is so necessary in order to solve this particular problem. To improve the ability to analyze, two types of activities are encouraged: (1) the use of an analysis chart, filled in by the children on which is a place for visible as well as invisible objects and (2) strategy sessions held between Inquiry sessions. The second is a great aid to isolating and identifying ways in which errors of analysis are made. An important part of these strategy sessions is the emphasis placed on focussing. By means of this technique, the pupil avoids sheer guesswork. If, for example, he wants to know what is in the tube, he could ask questions that eliminate things efficiently, such as "Is the material in the tube non-living?" "Solid?" "Metallic?" Out of these sessions soon comes the realization on the child's part that the ability to analyze can, and must be, sharpened by the use of questions such as: "Is there a cardboard tube?" "Is there anything inside the tube?" "Is there anything else?" After a few weeks of these kinds of experiences, the students become better aware of the necessity for accurate analysis.

Detection of Changes. Causality is usually regarded as the relating of two variables in time and space. One of these (the independent variable) causes the effect (the dependent variable) to vary, or change. To see how this idea relates to Inquiry strategy, let us consider again the problem shown in Fig. 1. Note that the problem statement itself (Why did the number of swings change?) contains evidence of a varieble in action.

This is an example of an effect (dependent variable). Something is responsible for this change. Therefore it is necessary that the pupil search for the other variable that possibly could be the cause of this change. Since the independent variable is invisible (the change of the center of weight, or oscillation), it becomes imperative that the pupil search for every change, visible and invisible, if he is to spot the proper cause-effect relationship. Again, as in analysis, the process of uncovering all changes does not seem to be a natural one with people and they must be encouraged to ask such kinds of questions as: "Did the tube change its position?" "Did the balls inside the tube change in some way?" "Did anything else change inside the tube?" Therefore, partially correct attempts at explanations and in-between strategy sessions provide a climate for maximal reinforcement in this area. Yet simply spotting all the changes is not always enough. Sometimes it is not obvious which two variables go together to form a cause-effect relationship. This isolation of the key variable is considered in the next section.

Determination of Relationships. Often the student is able to infer which two of any given variables are causally related. Occasionally, though, this is not the case and the pupil is at a loss to explain the problem at hand. Then it becomes necessary to be aware of the kinds of techniques available for isolating a variable. These are based on the idea that if only one particular thing were changed (all other things being equal), the observed variable would change in some particular way. For example, in reference to Fig. 1, the child might ask:"If only the outside tube is turned over, does the number of swings change?" The answer to this question is no. Since the shifting of the center of weight is the vital factor in this instance, the pupil can continue with this kind of question-asking strategy until he isolates this key variable. If at this point he is still in doubt as to the type of causal relationship between the center of weight and the number of vibrations, he can ask this kind of question: "As the heavy end of the tube drops lower, does the pendulum swing faster? the same? slower?" With questions such as these he can spot the kind of relationship (direct or inverse, for example) existing between the effect (as evidenced in the problem situation) and the cause (as inferred from the data). At this point, or earlier, any individual student may feel that he can explain "Why did the number of swings change?" If the explanation is correct and complete, the instructor tells him so and the problem-solving part of the session is ended.

Psychological Significance of the Inquiry Process

We have presented an analysis of the Inquiry task, indicating the formal task requirements of analysis, change and relationship. At this juncture the relationship between cognitive style and behavior during Inquiry becomes meaningful and relevant. It is our contention that the styles of categorization defined in this report, descriptive, relational contextual, and categorical-inferential are psychological predispositions related to the child's functioning in Inquiry. This relationship between Inquiry and Styles of Categorization is an interdependent one. Not only is the child's limited orientation toward processing data a function of his stylistic preference, but the Inquiry process is thought to influence the stylistic orientation. This point of view is based on the premise that styles are not necessarily immutable, but are modifiable through educative experiences. In effect, this is our major hypothesis.

Scanning Behavior. A first conjunction of Inquiry and cognitive style occurs when the child is faced with the task of examining the components of the science demonstration. One of the vital aspects of the descriptive, part-whole orientation is its emphasis on searching (scanning) for relevant information. From our point of view, this scanning behavior is a critical activity that the child employs in identifying ingredients of the problem. An Analysis of his scanning behavior as one manifestation of the child's cognitive style illustrates our point. Before the child sees the demonstration (see Fig. 1), he has his own ideas about the way forces and objects act and interact. If he has already acquired the concept of the laws of the pendulum, his chief task will be to gather enough data to indicate that this is the operating principle. However, if he has erroneous views, as we shall soon see, he must not only gather sufficient data but restructure his thought so that he can correctly explain the demonstration. In either case, the child must scan his memory system for cues to help explain the problem. The child with an inadequately structured conceptual schema must eliminate his faulty thinking first before he can go about the business of fact-gathering. For example, if the scanning of his memory indicates that the tube is vibrating at a specified frequency because of the length of the arc of the swing, he will attempt to explain the problem in those terms. The instructor tells him that his explanation is incorrect, but to keep on trying. His next step would be to scan for more cues that might be relevant or significant. He may arrive at the idea that the act of inverting the tube could be a possible cause of the change in frequency. When he attempts to explain the problem in terms of the inversion, he is now told that his explanation is correct, but incomplete. At this point, he is on the brink of structuring a concept. He is aware that his goal is within reach but that he has overlooked items of importance. He realizes that the global aspects of the stimuli and his own memory system are insufficient to solve the problem. Since there is an exploratory climate in Inquiry, he is free to continue his search; this time he must focus on all the factual details since he is weaving a new concept, each thread of which he must fit into place by himself. To do this, he rebuilds the demonstration mentally, using an episode chart as the vehicle to record details of the problem. For example, as he asks questions, such as "At the start, was there a tube on a string?" and "Was the tube turned over the second time?" he can indicate to a student assistant (or the instructor) a drawing or label to appropriately identify objects or events on the chart. In this way he scans the details of the demonstration from his memory in order to complete the drawing. If he neglects to scan his memory for enough data, if he overlooks anything, he will be faced with the instructor's response, "Correct, but incomplete," when he attempts another explanation.

For the individual whose preferential mode of operation is descriptive, which includes scanning for details, the analysis phase of Inquiry supports his orientation. On the other hand, for a child to whom descriptiveness is not a preferential mode of operation, this phase requires a modification of his approach. He is required to behave in ways contrary to his cognitive preference. Ultimately the child's cognitive structure might be reorganized so that scanning for parts in a whole stimulus is a readily available response when the situation requires it. Therefore, to accomplish an adequate analysis, he must engage in two kinds of scanning behavior: (1) scanning his own memory system for cues that might be significant or relevant to the problem and (2) scanning stimuli that are apparent to the senses, such as the problem demonstration, the episode chart, and the audio cues received from other class members as they ask questions. Theoretically, then, the pupil is encouraged to be quite flexible in his thought processes, reaching out for information in as many directions as his freedom and ability to be mobile permit.

Classificatory Behavior. In his search for the data that will aid him in his problem-solving process, the student must make some order out of the chaotic state of the stimuli. Some of the stimuli and data are relevant to the problem, others are not. To complicate matters, some of the data are not apparent to the senses. In order to find these bits of relevant data, especially those that are not very obvious, he must search as efficiently as possible, or eventually become very frustrated. Mentioned earlier was the use of focussing questions. How can these types of questions aid in the development of taxonomic relationships? First, the child has abundant opportunity to probe into the unknown, to search. Second, the use of focussing questions provides an efficient way to have these experiences. For instance, the pupil could guess what is inside the tube in Fig. 1 but he is apt to find that it is more efficient to conduct the previously mentioned series of questions; "Is the material in the tube non-living?" "Metallic?" "Non-metallic?" "Wood?", etc. With each question he is getting closer to the actual kinds of objects. Thus the bits of information are brought together on the basis of their class membership--a means for organizing the unorganized environment. In effect, the child is employing categories, possibly constructed for that particular task. Identifying characteristics of the categories enables him to reduce the disarray, create class relationships, and in the end deal with larger units of information.

Inferential Behavior. What other effect should the Inquiry process have on the psychological orientation of the pupil? A great many aspects of this process point to the fact that the child must attend to cues that are not manifest. To begin with, there are many objects in science problems that have stimulus properties. In Fig. 1 light rays bounce off the tube, string and hook to help create percepts. But it is suggested that an equal number of objects and events in the problem situation possess no overt stimulus properties; e.g., the spheres inside the tube, the changing of the position of the spheres, and last of all, the shifting of the center of weight. There is also another kind of situation that has no stimulus manifestation, for example, inferring that the shifting of the center of oscillation is the cause of the changing number of swings involves non-manifest cues. In fact, this cause-effect relationship, or any other ones for that matter, involves the making of inferences. Thus, before a person can solve a problem correctly and completely, he must be aware of the blatant and the obvious, and also be "set" to go beyond the given. Inquiry provides the climate for such experiences to develop.

Styles of categorization are conceptually viewed as intimately tied to the child's behavior in the Inquiry situation. His approach to the task, as we have said, is presumed initially to be determined by his stylistic predispositions. However, the educational requirements in Inquiry, of necessity, force him to employ different approaches to problem-solving. Irrespective of personal inclination, the child has to shift from one approach to another if he is to solve the problem. The task, then, puts the child into a cognitive conflict where his inclinations may be dysfunctional. Solutions come by way of shifting approaches. If the child does this, he not only solves the problem but also becomes aware of the need to vary his approach. Then, Cognitive Style may be altered because the child finds this a necessity in order to adapt.

Design of the Project

Classroom Procedures

In September 1963 seven elementary school teachers who had previously attended a workshop to learn Inquiry procedures agreed to teach some of their science classes by this approach. During that academic year there were enough subjects available to undertake a study comparing the differential effects of the Inquiry procedure and Conventional teaching on the cognitive functioning of children. Within each grade level (fourth, fifth, and sixth) the Inquiry groups (the Experimentals) and the Conventionally taught groups (the Controls) were exposed to as comparable amounts of science class time and science subject matter as was possible within the school situation. The only apparent difference between the groups of children was the type of teaching to which they were exposed in their educational setting.

The course of study was made up of five science concepts for each of the three grade levels. Each teacher spent three to four weeks of class time (about 100 minutes per week) on each concept. Table 1 lists the science concept areas that were taught at each grade level. The curriculum in the Inquiry classes generally consisted of three problems for each concept (see Appendix B). Occasionally a fourth problem was used to round out the lessons illustrating given science concepts. Inquiry classes usually spent approximately 70 of the 100 minutes in attempting to solve the problem under consideration. The remaining thirty minutes were spent in discussing the strategy techniques employed by the children. An essential ingredient missing from the control classes was the discussion of strategy, therefore, the Conventionally taught groups usually had more

TABLE 1

SCIENCE CONCEPTS TAUGHT IN PARTICIPATING SCHOOLS

GRADE 4	GRADE 5	GRADE 6
1. Force and motion--when an object is moving there is an imbalance of forces. When an object is resting, there is a balance of forces.	1. Gravity--the rate of acceleration is the same for different falling objects when air resistance is negligible.	1. Change of state--there is a rapid and tremendous increase in volume of a substance when changing from a liquid to a gas.
2. Heat Conduction--increased molecular activity in metals starts at the heat source; then it spreads outward from the heat source.	2. Friction--sliding friction depends on the kind of material, the condition of the surfaces, and the weight of the material.	2. Differential absorption--the absorption of radiation varies as a function of the color of a surface.
3. Electrical circuits--a simple series circuit is formed through a closed conducting pathway.	3. Physical-chemical changes--differences between physical and chemical changes are investigated.	3. Newton's Third Law--for every action, there is an equal and opposite reaction.
4. Leaf growth--as sunlight varies so do the growth characteristics of leaves.	4. Geological percolation--the downward percolation of liquids varies as the size of the rock particles.	4. Bernouilli's Principle--an increase in the speed of a fluid results in a lowering of the fluid's pressure.
5. Biological classification--living organisms are grouped on the basis of certain taxonomic characteristics.	5. Volume--the volume of a given amount of a substance is constant regardless of the shape of its container.	5. Machines--force is sacrificed for distance and vice versa in the use of the simple machines.

time spent on science subject matter, since all of their time was used for content.

The same teacher who taught the experimental group also taught the control group. Although there may appear to be some disadvantages to this, we believe this controlled for such variables as teacher personality and teacher skill in classroom management. It must be made patently clear that the teachers who taught under the Inquiry process were very much interested in it, but did not believe that Conventional teaching was necessarily inferior. In other words, in our opinion, the teachers had an exploratory, curious attitude, were skilled in the Inquiry techniques, and were interested in assessing the advantages of them, if any.

Subjects

In June, 1963, 120 fifth and sixth grade children in one school were given a battery of intellectual and cognitive style tasks. Preliminary analyses of these data suggested that there were significant differences between the control and experimental groups. On this basis a proposal was submitted to the Office of Education for extension and expansion of the project. As a consequence, in June 1964, an additional twenty sections of children were tested with the same instruments as the original 120. One difference in the new arrangement was that we added a fourth grade. Thus between these two one-year periods we had a total of 820 subjects representing a cross section of the Detroit population of fourth, fifth and sixth grade children. [1] However, as is the case in any educational research program, natural attrition reduced the number of subjects who had completed all testing instruments. The first reduction left 420 subjects, 140 in each of the three grade levels. This number was reduced further when we found it necessary to take the Iowa Achievement levels into consideration, having discovered that academic achievement level was related to Science Concept Achievement. Accordingly the experimental and control groups were matched as evenly as possible, using the Iowa composite score as the criterion. When this had been done, the data from 300 subjects were available for most analyses, 100 in each grade level. Each grade level consisted of 50 experimental and 50 control children. These groups of 50 were further divided into 25 boys and 25 girls, so that there were twelve groups of 25 children, making a total population sample of 300.

Testing Instruments

To each of the children in the experimental and control groups we administered a Science Concept Achievement Test (CET), the Cognitive Styles Task (SCST), and the Creativity Task of Torrance (FF). Thus the three areas of interest in this study, Science Concept Achievement, Cognitive Styles, and Creativity, were each assessed by an independent measure.

Science Concept Achievement Test. The child's concept achievement was tested using a cause-effect test, which consisted of the application of each of the five science concepts studied in the classroom for the particular grade (see Table 1). At each grade level, the CET test consisted of a sample problem and five curriculum associated problems, each of which illustrated a specific science area such as action-reaction or electrical circuits.

Each of these problems had four multiple answer sections. In scoring, one point was given for a correct choice in each section, making a total of twenty points if all choices were correct.

Efforts were made at establishing the reliability of the CET problems.

Three grade levels, five, six, and seven, had been used in a previous investigation of the reliability of this instrument. Data from a total of 131 children were obtained from a sampling of CET problems. The test consisted of four problems, a pair depicting the action-reaction principle and another showing the balance (and imbalance) of forces. It was hypothesized that if the test were reliable, a child who answered one problem from a pair correctly should answer the other also, and miss on both of them if he did not understand the concept under consideration. The data from these four problems were analyzed by a 2 x 2 contingency table and converted to a tetrachoric r which equalled .78. This indicated that the CET was fairly reliable in assessing Science Concept Achievement.

The validity of this type of instrument is rather difficult to establish. With a conventional achievement test, one has assumed in the past that if the child answers the questions appropriately and gets a high score on them at the end of the term, he has mastered the material. Validity becomes, then, a moot point. We have confidence that this test too has acceptable construct validity, since it was made up by science teachers.[2]

Cognitive Styles Task. The cognitive styles of the children were assessed by means of a group form of a sorting test previously employed by Sigel (1961). The rationale of this instrument is as follows: Given an array of items, individuals will order these on the basis of preferences that already exist. The preferences expressed in this ordering procedure reflect "styles of categorization." Previous research, however, has limited these tasks to individual sessions. In order to facilitate large scale assessment of styles of categorization, a group form was devised.

A group of pictures representing human, vehicle, furniture, tool, and food categories was selected as the content of this task. Three items representing diverse categories were placed on a card and the child is asked to select any two of these three on the basis of their similarity or belongingness and indicate the rationale for each (see Appendix C for sample). A thirty-five item task was constructed allowing the child to cover a wide range of content within the categories defined.

The test was administered to a group of children who were asked to respond to each set of 3 pictures by noting how any two of the three items in the set go together. The child could list as many or as few combinations as he wished. For each child a minimum of 34 responses were possible, but there was no maximum, for this depended on the speed and fluency of the child's responses.

This task had been administered in 1962 by Scott to a group of children in grades five through seven. On the basis of the preliminary experience it appeared this task is appropriate for children as early as the fourth grade (Scott, 1962).

The responses to each set of pictures were classified into any one of the following categories: *descriptive part-whole*, *descriptive-whole*, *relational-contextual*, *categorical-functional*, *categorical-class-naming*, and *categorical-attribute*. Each of these is defined as follows:

1) Descriptive part-whole (DPW). Labels denoting observable parts of a figure, e.g. "they all have shoes," "they are all gray."

2) Descriptive-whole (DW). Labels denoting global aspects of stimuli where the identifying cues are obvious and apparent, e.g. "men."

3) Relational-contextual (R). Labels denoting a functional or thematic interdependence between two or more instances in an array,

e.g. a picture of a man with a saw and a block of wood, "the man cuts the wood with the saw."

4) Categorical-functional (CF). Labels applied to items on the basis of inferred use, where every instance of the class is an instance of their use. For example, stimuli depicting vegetables or fruit, and the label given "these are things we can eat."

5) Categorical-class-naming (CN). Labels indicating that every member of the array is an instance of that class; this is in effect a taxonomic statement. For example, a chair and a table are grouped together because "they're both furniture."

6) Categorical-attribute (CA). Labels providing only one inferred attribute. For example, statements such as "they are happy" or "they are handicapped."

Each statement made by the child that was scorable within any of these categories was labelled accordingly. Thus the total score for each child could vary from 34 (the first item being a sample) to an indefinite number as indicated previously. It must be kept in mind that the scores given are dependent one upon the other, and consequently, our statistical analyses took this into consideration. We shall proceed to discuss the scoring in some detail.

As indicated, we scored the child's statement by defining the unit of response that would fit into our system and labelling it accordingly. Thus, for example, if the child said, "They have shoes;" "They are all tall," this would comprise two descriptive part-whole ideas, each phrase of which is scorable within the system, and the child would be given a score of "2" under part-whole. For this report we used only the child's initial selection of a pair of pictures. This response was further broken down as follows: First, the initial label, the very first scorable response, given by a child was scored to control for frequency and fluency, and for all children we then have the same total score of 34. A second score was what we will refer to as our total labelling score, and this includes all scorable units the child gave to his initial selection of a pair of pictures. Thus, the range here can be from 34 to an undefined total. These scores provide us with the child's preference in his classification behavior. In addition we are interested in assessing the degree to which a child shifts his interests or his attention from one stimulus to the other and from one category to the other. In effect, we are interested in the flexibility of categorization as well as the flexibility in employing different stimuli.

Consequently, we scored the child's responses to determine the amount of shift between cards from one SCST category to another on the initial labelling. Using such categories as descriptive, relational-contextual and inferential, we counted the number of times the child shifted among these categories on his initial labelling from one card to another. This provided us with a between card shifting score, the FPCS.

The amount of category shifting that a child did within a card was measured by counting the number of different times a style of categorization dimension was changed within each card. These are called our CS scores. Thus we have two category shifting scores, one dealing with the shift from one card to another (the FPCS) and the other dealing with the within card shift (the CS). This, then, enables us to assess the degree to which the child is flexible when he has a given stimulus before him, in contrast to his flexibility when he has moved from one set of stimuli to another. This former is more an instance of perseveration perhaps than the latter.

A third type of shifting concerned itself with the actual materials themselves. We were interested in the degree to which the child could surrender his working with a pair of pictures and move on to another combination. This shifting of the use of pictures we refer to as our SS scores, stimulus shift.

Test-retest reliability was obtained for one group of 34 fourth grade children where the task was administered twice, five weeks apart. In Table 2 are shown test-retest correlations for each of the major categories. As can be seen, the range of test-retest correlations for each of the categories is from .45 to .83. These results are similar to split half reliability measures employed by Sigel (1961) on his data with the exception of the descriptive part-whole (DPW) response where he found a range of reliability from .51 to .61, depending upon the age of the child. However, his results tend to show some consistency in the application of these categories to similar tasks which are consistent with what is reported here. In general, for this type of an instrument, we have some confidence that we are dealing with a matter of moderate reliability.

TABLE 2

SCST Test-Retest Correlations

N = 34

DPW	DW	R	CF	CN	CA
.45	.64	.83	.70	.83	.68

The coding of these responses is not purely mechanical and consequently intercoder reliability was established. The average coder reliability was over 98% employing 1,000 instances as the sample of responses from which to work. This seemed to indicate that the scoring was highly reliable.

Divergent Thinking. Divergent thinking of the child was assessed by the Creativity Task (FF). This task is based on the work of Guilford and Merrifield (1960), Torrance (1962), and others. The child is given a single stimulus word; e.g., brick, and asked to think in as many different ways as he can about that particular item. It is assumed that the individual who provides a wide array of ideas about this stimulus word is "thinking divergently," one definition of creativity. It also seems reasonable that the individual who branches out in many different directions is more likely to employ the same divergent approach to problem-solving and hence solve problems more readily.

The FF task used in this study employed two sets of words (see Appendix D). The first set (brick and screwdriver) was employed to assess the child's divergent thinking with concrete objects. The second set (honest and good) was used to evaluate his thinking with abstract ideas. The child was then asked to think of as many different ways as possible that each of the words could be used. The FF task was not timed; however, most children were finished in approximately fifteen minutes. The number of words reflecting different categories of uses was the basis for scoring.

Summary

To summarize our design, briefly we have administered three tasks to 300 boys and girls in grades four, five, and six in the Detroit Public School system. One hundred and fifty of these children were taught five science concepts by an Inquiry approach and the remaining ones by a Conventional approach. The same teacher taught both the experimental and the control groups, thus controlling for such variables as teacher personality, teacher management skills, etc. The Inquiry process is sufficiently structured to reduce the amount of carry over of one method to the other.

After the course of study was completed, each of these children was given the cause-effect test (the CET), the cognitive styles task (the SCST); the "uses" task (FF).

Analyses of these data comparing one grade with the other and the sexes within each grade will be dealt with in the next section.

CHAPTER IV

RESULTS AND DISCUSSION OF WITHIN GRADE LEVEL FINDINGS

From the previous discussion we have learned that the Inquiry process has, in the past, been a unique but questionable vehicle for learning. This study then was designed to provide some answers to these kinds of issues: (1) Would the strategy of Inquiry help children to achieve science concepts as well as or better than conventionally taught children? (2) Would the Inquiry process be as effective as Conventional Teaching with boys as with girls? (3) Would the Styles of Categorization and Divergent Thinking be influenced more by the Inquiry procedure than by Conventional Teaching?

Overview of the Findings

Before proceeding with the detailed discussion, let us capsulize the findings. First, Inquiry children did achieve science concepts as well as, or better than conventionally taught children in grades four and six. However, in grade five the Inquiry taught children achieved science concepts significantly better than the control pupils.

Secondly, no significant differences in Science Concept Achievement were found between boys and girls in either teaching condition.

Third, the cognitive functions of children were definitely affected by Inquiry. There were no significant differences to report for Divergent Thinking between the two groups, however significant results were obtained for Styles of Categorization. Each grade level is characterized by its own unique set of findings. In grade four, the Inquiry pupils, in their Initial responses to the SCST, were significantly more inclined to classify by class-labelling and less by function than the control children. In grade five, no significant differences were found between the sexes and teaching methods for any of the SCST categories; however there were significant interaction effects between Sex and Teaching Condition for Total Labelling in the descriptive whole and class-naming categories. In grade six, the Inquiry children, in their Total Labelling responses to the SCST, used significantly more descriptive, part-whole and categorical attribute labels than the Controls. In addition, they were significantly more flexible in their ability to shift stimuli and methods of categorization than the Control children.

Science Concept Achievement

Several criticisms have been levelled at the Inquiry process. One of these stems from the idea that this method might produce a negative reaction within males because of the emphasis on verbal skills. Again, a second criticism has been that, although there is emphasis on developing problem-solving strategies in Inquiry, children would not achieve science concepts to the degree possible under conventional teaching. Examination of the data that follows should provide some interesting answers to these criticisms.

First of all, reference to Table 4 indicates that there were no significant differences between the sexes for concept achievement at any of the grade levels. Neither were there any interaction effects of significance between Sex and Condition of teaching. Second, Table 4 also indicates that there were no significant differences between teaching conditions in grades four or six. However, in grade five we find that there is a significant difference between methods of teaching where the

TABLE 3

MEANS FROM THE CET DATA

Grade	Experimental		Control	
	Boys	Girls	Boys	Girls
4	12.00	12.72	11.56	11.24
5	9.16	9.76	7.72	8.32
6	9.80	10.12	10.04	8.84
Grand Means	10.32	10.83	9.77	9.43

Inquiry groups (Experimentals) do better than the Controls (see Table 3). These two findings will be expanded in the discussion that follows.

Sex Difference

The area of science has frequently been referred to as the domain of the male sex, yet studies have indicated conflicting results in this regard. For instance, (Duetsche (1943) has shown that there is no clear-cut evidence of a native superiority of boys over girls in the area of science. Our investigation tends to support her finding, in spite of the presupposition that the verbal orientation of the Inquiry process might favor girls in the classroom. Therefore, at this point it is clear that significant sex differences are not found for Science Concept Achievement in the later elementary school grades.

Teaching Methods

The fifth grade has provided an interesting finding in comparing the two methods of teaching. Is the fact that the Inquiry groups were better than the Controls in Science Concept Achievement at this grade level a

TABLE 4

ANALYSIS OF VARIANCE FOR SCIENCE CONCEPT ACHIEVEMENT

Grade Four

SOURCE	df	SS	MS	F	p
Condition	1	23	23	.13	-
Sex	1	1	1	-	-
Interaction	1	7	7	-	-
Within	96	1746	181.9		
Total	99	1777			

Grade Five

SOURCE	df	SS	MS	F	p
Condition	1	51	51	4.37	<.05
Sex	1	10	10	-	-
Interaction	1	0	0	-	-
Within	96	1119	11.66		
Total	99	1180			

Grade Six

SOURCE	df	SS	MS	F	p
Condition	1	7	7	-	-
Sex	1	5	5	-	-
Interaction	1	14	14	1.01	-
Within	96	1325	13.80		
Total	99	1351			

matter of chance or is there some explanation that might shed light on these results? The fifth grade has frequently been considered an unusual school area to investigate. For instance, Scott (1964) indicated that ten-year old children (mostly fifth grade pupils) reacted uniquely to the variety of testing instruments to which they were exposed. His findings showed that, by Bartlett's test, these pupils were less variable on an inductive reasoning test than children a year older. He suggested that this lack of variability might be related to the fact that all patterns a child might induce were visualized for him on the test. The child at this age indicated a preference for this highly structured task rather than the scheme of classification of the cognitive style task which required his own personal remarks and preferences. He apparently preferred to limit himself to the "given." 3

In the CET, we find a task somewhat parallel to the inductive reasoning test and it seems reasonable to assume that the same phenomena are operating. The CET is a multiple choice test with a picture depicting each science concept. Everything is provided for the child that is necessary to complete the task. He has little need for flexibility in selecting the predetermined answers. There are then some strong similarities to the inductive reasoning test.

Still, this does not explain entirely why the experimental group did significantly better on the CET, since the structure of the test was operating equally well for both groups. However, the child in the experimental situation had an additional influencing factor--the strategy of Inquiry. It is suggested that the fifth grade child is in a transition period where his cognitive operations are in a state of flux. This is consistent with Piaget's contention (Inhelder and Piaget, 1958) that at about the eleventh or twelfth year the child is entering the early stages of logical thought. Before this, he is in a period of transition between concrete operations and logical thought. In his efforts to make sense out of things, he attempts to find new relationships, to extend his thinking. However, he just doesn't have enough cognitive aptitudes to analyze all of the variables that come his way. When these variables are left unanalyzed, they may later reappear as disturbing influences. It may be that these disturbances are at least part of the reasons why the fifth grade child prefers structured situations where a degree of analysis has already been accomplished for him.

Inquiry strategy may have been a cogent factor that appeared on the scene in an ideal time sequence. To illustrate, in attempting to solve the problem depicted in Fig. 1 in chapter three (the swinging tube) the Inquiry child is given many opportunities not only to analyze objects and events but also to isolate variables. It is this latter process that may be of great value to him just when he is in need of something to "hold on to." During Inquiry, he is encouraged to ask questions as: "All other things equal, if we change only the weight of the balls, will the tube swing the same?" These types of questions are a part of his strategy development. He is analyzing variables, not haphazardly, but with the idea of isolating the key causal-relationship. Of course, he is very crude in his attempts, not approaching the thirteen-year old, for instance, in his ability to be logical in thought. But he has acquired somewhat of a mental strategy, and at a time when its introduction seems to have been efficiently advantageous. We suggest that the reason the Control child does not do as well as the Inquiry pupil in grade five is that the conventional teaching program does not enable the child to extend his thinking processes when he is most ready to do so. Consequently, he is slower in acquiring problem-solving strategies. This may account for the lack of significant differences, as we shall see, in the discussion for grade six.

In the sixth grade, we find no significant differences between the Inquiry and Control groups in Science Concept Achievement. But this finding must be interpreted in the light of the fact that the Inquiry children spend less time in substantive science concept learning than do the Controls. This suggests that Inquiry children are learning content efficiently while at the same time are acquiring a strategy. Therefore, the lack of significant differences between the two groups does indicate that the two teaching conditions should not be viewed as having the same values for the child.

What of the fourth grade in Science Concept Achievement? Here there seems to be a situation similar to that reported for grade six, in that the Inquiry groups did not differ from the Controls. We think that this is a result of the Inquiry child's beginning competence in assimilating the Inquiry experience into his problem-solving behavior. As with the sixth grade, these children can effectively cope with science problems even though they are spending less time on them than the child in conventionally taught classes. They apparently have acquired the necessary cognitive structures and are able to utilize relevant mental operations such as abilities to detect relationships, to make inferences and to evolve classifications.

Divergent Thinking

Another purpose of this project was to investigate the degree to

TABLE 5

ANALYSIS OF VARIANCE OF
DIVERGENT THINKING (FF)

Grade Four

SOURCE	df	SS	MS	F	p
Condition	1	5	5	-	-
Sex	1	17	17	-	-
Interaction	1	13	13	-	-
Within	96	4768	49.67		
Total	99	4803			

Grade Six

SOURCE	df	SS	MS	F	p
Condition	1	57	57	1.57	-
Sex	1	40	40	1.10	-
Interaction	1	102	102	2.82	-
Within	96	3477	36.22		
Total	99	3676			

TABLE 6

MEANS FOR THE FF DATA

Grade	Experimental		Control	
	Boys	Girls	Boys	Girls
4*	13.28	13.20	13.56	12.00
6	12.56	13.32	13.08	9.80

*Grade 5 data are missing due to testing technicalities.

which the method of teaching affects the divergent thinking (creativity) of elementary school children. Torrance (1962) and others have been studying the different aspects of the creative mind during recent years. Their investigations have challenged the emphasis that the schools have placed on the ability to "get the right answer," commonly referred to as convergent thinking. As a result, divergent thinking is currently regarded as one feature of the flexible, creative mind that is highly desirable in the world of problem-solving. The Inquiry process supposedly encourages the desire to explore the environment mentally, to "go beyond what is given." Should not a teaching method such as this bring out, or develop the potential divergent thinking ability of children in a significant manner? Inspection of Table 5 indicates that there may be no difference at all in Divergent Thinking data in any of the groups of children. These data could be most surprising, but consider the background material. It was suspected that the Iowa Achievement scores were an influencing factor on a number of test items, one of which was divergent thinking. Before equalizing the experimental and control groups on the Iowa scores, the Inquiry children were significantly better at divergent thinking on the whole. The results now available indicate that, apparently, this task (FF) is closely related to the so-called standardized I.Q. measures. The results of this investigation apparently have uncovered an inherent weakness in the divergent thinking task, either indicating a need for its modification or that brighter children are more creative. Later, we shall see that the flexibility of thought that Inquiry supposedly would encourage is definitely detectable in the data for the styles of categorization.

Styles of Categorization

In considering the analyses within each of the three grade levels, we will present a discussion of the effect of the teaching method on the cognitive styles of children. 4

Grade Four Results and Discussion

The first item of interest is in Table 7 where there is a significant difference in teaching method (Condition). Reference to the means in Table 10 shows that the control groups have higher means in both Initial and Total Labelling methods of tabulation in the categorical functional area. This finding is striking since it is the only significant item in this grade where the control children are more productive of SCST labels than are the Inquiry (Experimental) groups. A first glance would indicate that conventional teaching may hold an edge over the Inquiry approach at a grade level when cognitive exploration needs encouragement. But this is not necessarily true. The Inquiry process places no premium on the type of behavior that it takes to categorize stimuli according to functional characteristics. For example, the child who observes the problem shown in Fig. 1 must observe the functional part of the demonstration (the swinging of the tube and its inversion). After this, however, he is aware that the problem can be solved only if he can detect the non-apparent change that might be related to the difference in the swing. In order to eliminate the relevant from the irrelevant factors in the problem, he must focus his attention on the invisible as well as the visible details in the stimuli. He is aware that something could be inside the tube. This hidden material, if present, could be important. His main focus, then, is on the possibilities of

TABLE 7

ANALYSIS OF VARIANCE OF SCST INITIAL LABELLING WITHIN GRADE FOUR

Categorical-Functional (CF)

SOURCE	df	SS	MS	F	p
Condition	1	35	35	5.24	$<.05$
Sex	1	14	14	2.09	-
Interaction	1	30	30	4.49	$<.05$
Within	96	641	6.68		
Total	99	720			

Categorical, Class-Naming (CN)

SOURCE	df	SS	MS	F	p
Condition	1	57	57	3.69	$<.10$
Sex	1	5	5	-	-
Interaction	1	58	58	3.75	$<.10$
Within	96	1483	15.45		
Total	99	·1603			

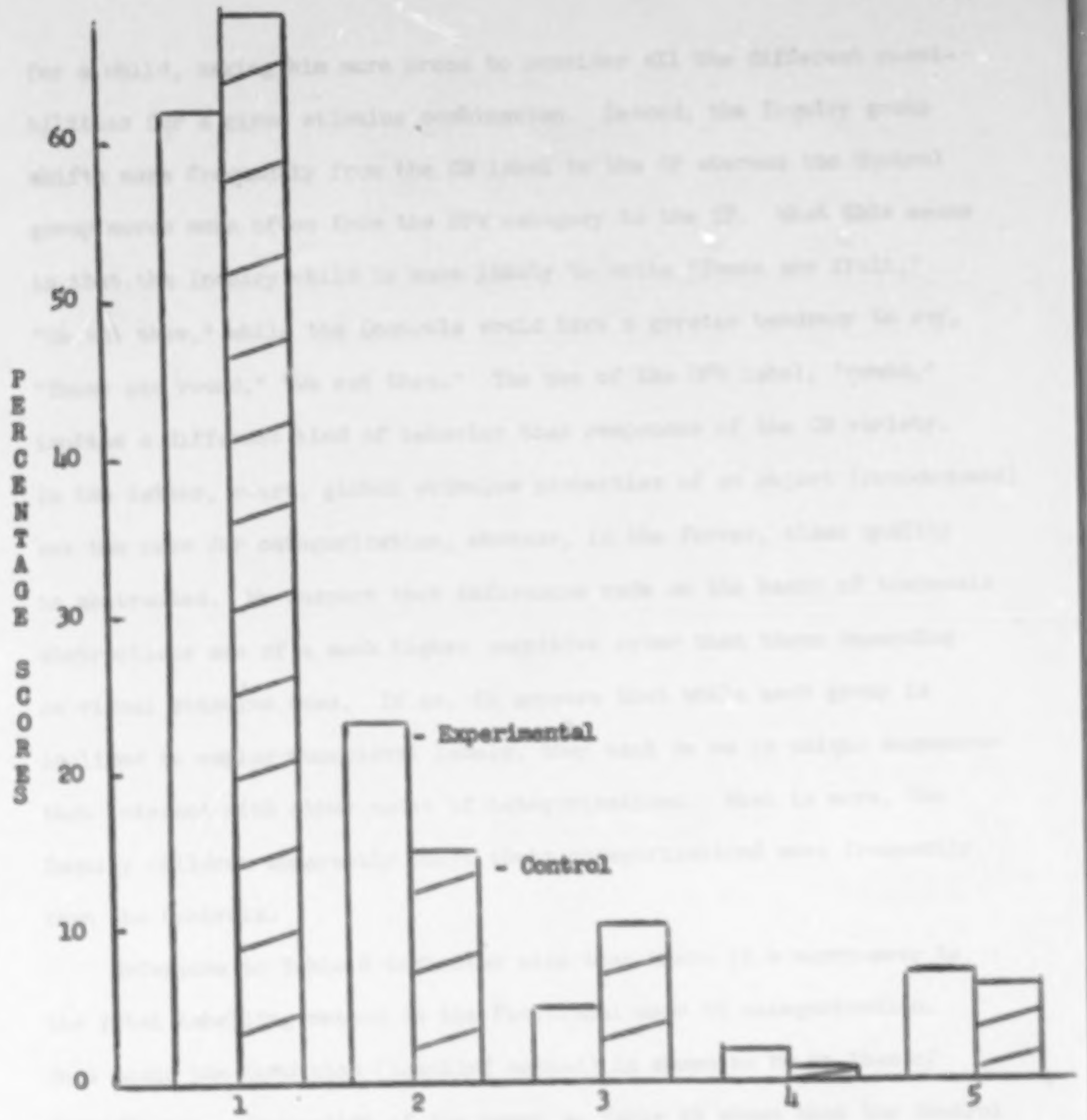
Categorical-Attribute (CA)

SOURCE	df	SS	MS	F	p
Condition	1	12	12	1.23	-
Sex	1	16	16	1.64	-
Interaction	1	64	64	6.57	$<.01$
Within	96	934	9.73		
Total	99	1026			

non-manifest materials and the discovery of their characteristics through focussing questions, such as "Is the material solid?" "Metallic?" "Steel?" Notice that he is not too concerned about the swinging or turning of the tube, the functional aspects.

However, since the total number of initial labels is the same for both groups (34), with what kind of label did the Inquiry child compensate for his reduction in functional labels? Inspection of Table 7 shows that there is another interesting finding concerning Condition in the use of class-naming labels. From the means in Table 10, we find that the Inquiry group frequently provides labels such as "fruit," "furniture," and "animals." This finding is pertinent since children who employ these are grouping things by abstract classes. It would seem as though the child who is focussing in Inquiry ("Are these non-living?" "Solid?" "Metallic?") would be practicing a class-naming type of behavior. If so, it is not too surprising that the Inquiry child makes up for his reduced number of functional labels by increasing his use of the class-naming type.

Further exploration of the functional and class-naming categories reveals some interesting interactions peculiar to each group of children. To pursue this, we considered the use of a particular CF label, "We eat these" or "eat," wherever it was found in a fourth grade child's response pad. In order to offset the fluency factor, all pertinent data were converted to percentage scores so that qualitative, rather than quantitative results could be analyzed. These data are found in Fig. 2 and include two differences worth noting. First, the Inquiry group used this label alone less frequently than did the Controls. This is not surprising since the strategy of Inquiry provides an exploratory climate



1 - Use eat alone, no shifting to or from other categories

2 - Shifting from CN to eat (CF)

3 - Shifting from DPW to eat (CF)

4 - Shifting from R to eat (CF)

5 - Shifting from CA to eat (CF)

Fig. 2 - Analysis of Shifting Behavior with one Categorical Functional Label--within grade four

for a child, making him more prone to consider all the different possibilities for a given stimulus combination. Second, the Inquiry group shifts more frequently from the CN label to the CF whereas the Control group moves more often from the DPW category to the CF. What this means is that the Inquiry child is more likely to write "These are fruit," "We eat them," while the Controls would have a greater tendency to say, "These are round," "We eat them." The use of the DPW label, "round," implies a different kind of behavior than responses of the CN variety. In the latter, overt, global stimulus properties of an object (roundedness) are the cues for categorization, whereas, in the former, class quality is abstracted. We suspect that inferences made on the basis of taxonomic abstractions are of a much higher cognitive order than those depending on visual stimulus cues. If so, it appears that while each group is inclined to employ functional labels, they each do so in unique sequences that interact with other modes of categorizations. What is more, the Inquiry children apparently shift their categorizations more frequently than the Controls.

Reference to Table 8 indicates also that there is a carry-over to the Total Labelling method in the functional mode of categorization. Once again the Condition (teaching method) is shown to be an item of significance. Inspection of the means in Table 10 shows that the Control groups, as indicated earlier for the Initial Labelling method, provided more of these labels than did the Inquiry groups. These results are interesting since this is the only significant finding in the Total Labelling method for the fourth grade. Up to now, this grade has been characterized by reacting quite strongly in its Initial Labelling to stimulus situations. A plausible explanation for this finding lies in

TABLE 8

ANALYSIS OF VARIANCE OF TOTAL LABELLING WITHIN GRADE FOUR

Categorical-Functional (CF)

SOURCE	df	SS	MS	F	p
Condition	1	85	85	4.59	<.05
Sex	1	3	3	-	-
Interaction	1	31	31	1.67	-
Within	96	1776	18.5		
Total	99	1895			

TABLE 9

ANALYSIS OF VARIANCE OF BETWEEN CARD SHIFTING BEHAVIOR (FPCS) WITHIN GRADE FOUR

SOURCE	df	SS	MS	F	p
Condition	1	0	0	-	-
Sex	1	0	0	-	-
Interaction	1	88	88	5.09	<.05
Within	96	1659	17.28		
Total	99	1747			

the fact that the children in this grade, especially the Controls, shift categories infrequently, preferring to use the same classification scheme for a series of verbal labels. Therefore, it seems reasonable to assume that these findings are an extension of those found earlier for the CF category.

Not all of the results are straightforward Sex or Condition differences in the use of SCST labels. There are also interaction effects between these that are of significance in two of the six methods of classificatory modes. Worthy of note is the fact that all of these interaction effects are on the Initial Labelling method of tabulation. To begin with, this means that at the fourth grade level the first glance at a stimulus situation provides some remarkably unique reactions. In Table 7 we find evidence of these interactions for the functional, class-naming, and attribute categories. Examination of the means in Table 10 reveals some interesting facts. For the functional category, the control boys are higher in mean scores than the other three groups. In the class-naming category, however, the experimental boys are the highest, control boys lowest, and both girl groups are about the same. In the attribute category, the experimental boys again are the lowest while the other three groups have close to the same mean scores. This may indicate that the boys in Grade four are affected quite dramatically by the teaching method, this at a grade level when social pressures seem to be intense.

The Inquiry process has indicated, then, a measure of effectiveness in shaping the mental activities of boys. It may be related to the fact boys are still very much in the concrete operations stage described by Piaget. At this age, the child is able to combine sub-classes into supraclasses and to reverse the process by isolating a subclass from a supraclass. The Inquiry process undoubtedly encourages this process as evidenced by the SCST findings. On the other hand, the girls do not seem to respond to the Inquiry program in the same way as the boys. Perhaps among the girls there are beginnings of change and the approach of a new stage. If this be the case, one might expect the girls to be involved in more searching behavior than the boys in their efforts to stabilize their environment.

Indeed, in the last set of findings we find evidence of this idea. In Table 9 there is a significant interaction between the Teaching Method and Sex for category shifting behavior between cards (FPCS) on the Initial Labelling. From the means in Table 10 we find that the scores of Inquiry girls are higher than the other groups while the control boys have means that are the lowest of the four sets. Evidently the Inquiry girls have been stimulated by the program to scan their environment with significantly more variation. Later, it becomes increasingly evident that girls are much more likely than boys to shift in their categorization behavior. It might be possible that the Inquiry process is also stepping up the girls' transition between the stages of concrete operations and logical thinking.

Grade Five Results and Discussion

Table 11 shows that there is a significant interaction between Condition and Sex for both the descriptive whole (DW) and class-naming (CN) SCST categories. Table 10 indicates that the same pattern is established for both interactions: the experimental girls and control boys have the highest mean scores in both cases. Sigel (1963) has indicated

TABLE 10

MEANS FOR THE SCST DATA

Data Tabulation Method	GRADE 4				GRADE 5				GRADE 6			
	Experimental		Control		Experimental		Control		Experimental		Control	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Initial Labelling												
DPW	8.32	7.88	7.84	7.92	7.60	6.84	7.68	7.52	8.44	8.60	7.48	7.68
DW	7.80	7.40	5.84	7.68	5.80	7.36	7.00	6.00	7.28	7.64	7.28	8.56
R	2.48	3.12	3.28	3.48	4.32	4.44	3.64	4.52	4.16	3.08	3.32	2.68
CF	2.84	3.20	5.12	3.28	5.51	3.60	4.48	4.12	3.00	3.40	3.24	5.20
CN	8.16	6.20	4.80	6.24	4.68	6.12	5.84	5.12	5.60	4.92	6.64	5.20
CA	3.52	5.92	5.80	5.00	5.52	5.12	4.80	5.16	4.92	5.24	4.76	4.64
Total Labelling												
DPW	25.32	30.28	26.08	24.36	15.28	30.48	16.44	17.40	27.92	31.28	13.92	12.96
DW	9.16	9.36	7.48	9.32	6.28	8.60	9.90	6.84	8.64	9.04	8.72	9.08
R	2.96	3.40	3.36	3.80	4.52	4.60	3.76	4.68	4.68	3.56	3.48	2.80
CF	5.00	5.76	7.96	6.48	5.44	6.88	5.88	6.56	5.48	7.28	5.48	6.20
CN	10.32	7.96	6.88	7.80	5.20	8.20	6.68	5.88	8.12	7.64	7.32	5.56
CA	7.28	10.32	8.88	9.48	8.00	10.76	8.00	9.08	10.04	11.84	7.56	5.80
Shifting Scores												
FPCS	18.36	19.72	17.80	20.08	17.56	20.20	18.84	19.76	20.56	20.96	18.72	18.96
SS	8.92	13.16	5.96	9.24	7.76	14.96	9.52	17.24	19.64	22.08	11.12	12.08
CS	3.80	6.36	2.52	4.36	4.88	7.16	4.80	8.40	6.60	8.56	4.52	4.88

TABLE 11

ANALYSIS OF VARIANCE OF SCST TOTAL LABELLING WITHIN GRADE FIVE

Descriptive-Whole (DW)

SOURCE	df	SS	MS	F	p
Condition	1	0	0	-	-
Sex	1	7	7	-	-
Interaction	1	81	81	4.87	<.05
Within	96	1597	16.64		
Total	99	1685			

Categorical, Class-Naming (CN)

SOURCE	df	SS	MS	F	p
Condition	1	4	4	-	-
Sex	1	30	30	1.43	-
Interaction	1	91	91	4.35	<.05
Within	96	2010	20.94		
Total	99	2135			

that there is a high correlation between these two categories. Both methods of labelling are concerned with the global aspects of stimuli. It could be that the two groups just mentioned are quite high in these labelling scores, but for different reasons. For the experimental girls, it is suggested that the focussing aspect of the Inquiry program is beginning to affect their behavior, and much more so since they are approaching the logical thought stage. It could be that the Inquiry strategy is especially timely in the fifth grade for the girls. However, for the control boys, it is felt that any explanation lies mainly in the global approach used in DW labelling. Inspection of the means in Table 10 shows that, although the control boys' mean is different from that of the experimental boys and control girls, their mean score is only slightly higher for the categorical, class-naming category. Where the control boys are quite different is in the DW Total Labelling category for which they have the highest mean score of the four groups. We suggest that these boys are not yet observant of the details of their environment, preferring to scan stimuli for gross characteristics. The conventional teaching method did not stress detailed systematic analysis of science materials and demonstrations. It seems reasonable that these control boys, who apparently are in the midst of a transition period, react to environmental stimuli without attending to details which might confuse or upset their ideas of the way things should go.

Again, there is more evidence that the girls in this grade are in the incipient stages of important change. Observation of Table 12 indicates that, on both kinds of shifting behavior, there are sex differences of significance. The means in Table 10 show that the girls are much more flexible in their ability to shift stimuli or methods of categorization.

2

TABLE 12

ANALYSIS OF VARIANCE OF SCST SHIFTING BEHAVIOR WITHIN GRADE FIVE

Stimulus Shifting Behavior (SS)

SOURCE	df	SS	MS	F	p
Condition	1	102	102	-	-
Sex	1	1391	1391	7.46	<.01
Interaction	1	2	2	-	-
Within	96	17890	186.35		
Total	99	19385			

Category Shifting Behavior within Cards (CS)

SOURCE	df	SS	MS	F	p
Condition	1	8	8	-	-
Sex	1	216	216	11.28	<.01
Interaction	1	11	11	-	-
Within	96	5244	54.625		
Total	99	5479			

Earlier, Scott (1962) found that ten-year old girls were more stable than boys in their organization of environmental stimuli. Not only does this current investigation substantiate the previous one but it points to the possibility that girls may be a bit more advanced than boys in their cognitive capacities, regardless of the method of teaching. It might be pointed out that this could represent the boys' adverse reaction to a verbally-oriented task. However, we shall see that this does not hold true for grade six.

Grade Six Results and Discussion

This grade probably has the most significant findings of this investtigation. Apparently many mental activities are reaching a critical stage of development. It was in this grade that Suchman (1962) uncovered his important findings.

It could be said that history repeats itself, at least in these data. Reference to Table 13 indicates that the sixth grade has somewhat the same reaction to categorical-functional labelling as did grade four. In both cases the control groups provided more of these labels (CF) than did the Inquiry children (see Table 10). It would be repetitive to go over the reasoning inspired by these data again, since they are so nearly the same as that already covered. Scott (1962) indicated that eleven-year old boys provided significantly fewer of these labels than did ten-year old boys. Sigel (1961) has also uncovered the same trend. There is one additional finding that is important: girls provide more of these CF labels than do boys. It could be that girls, in a practical approach to life, attach more value to the functional than to the abstract qualities of environmental stimuli. It must be kept in mind that these data are

TABLE 13

ANALYSIS OF VARIANCE OF SCST INITIAL LABELLING FOR GRADE SIX

Categorical-Functional (CF)

SOURCE	df	SS	MS	F	p
Condition	1	26	26	4.19	$<.05$
Sex	1	35	35	5.65	$<.05$
Interaction	1	15	15	2.42	-
Within	96	595	6.2		
Total	99	671			

TABLE 14

ANALYSIS OF VARIANCE OF SCST TOTAL LABELLING FOR GRADE SIX

Descriptive, Part-Whole (DPW)

SOURCE	df	SS	MS	F	p
Condition	1	6529	6529	13.95	$<.01$
Sex	1	36	36	-	-
Interaction	1	116	116	-	-
Within	96	44900	467.71		
Total	99	51581			

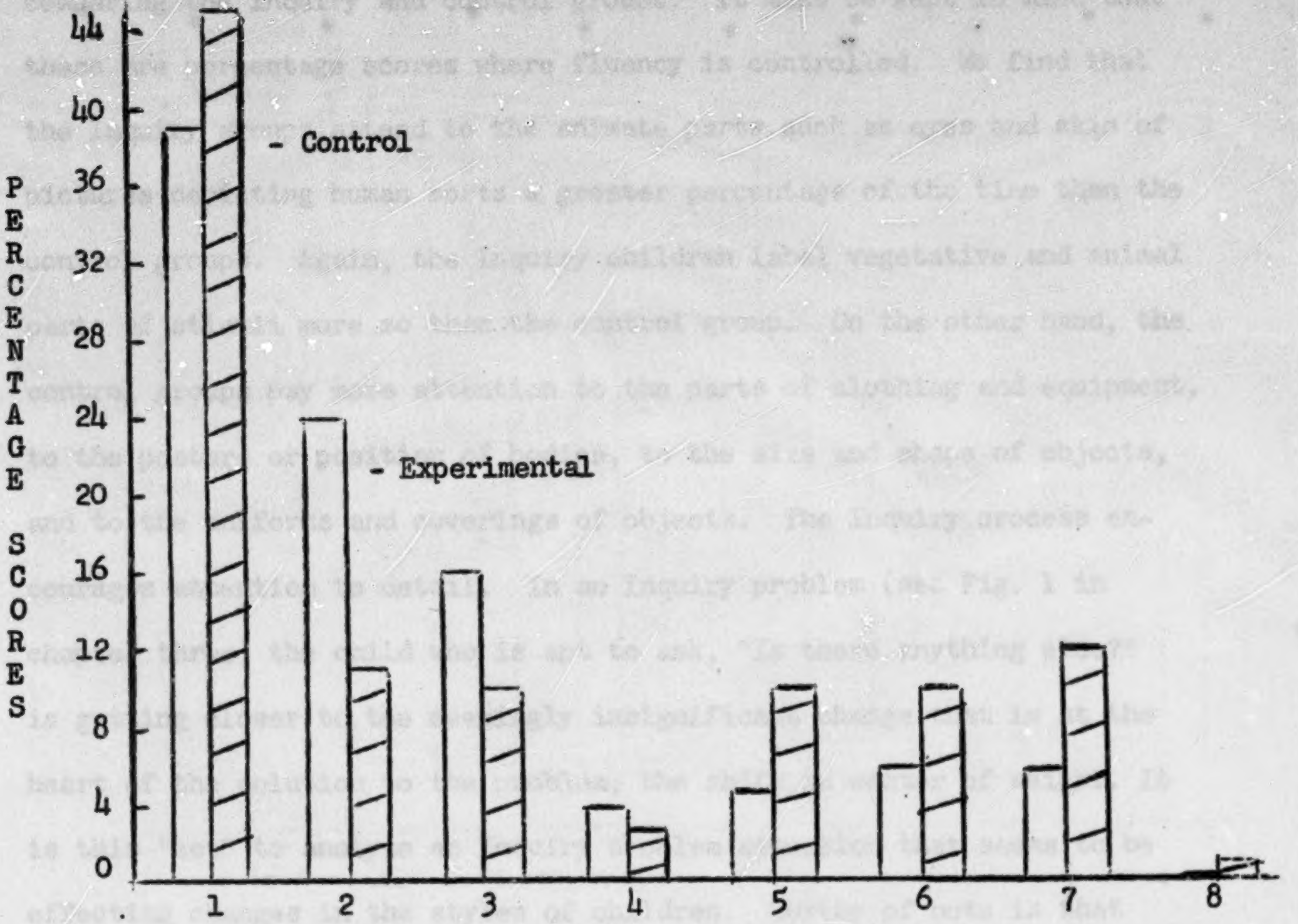
Categorical-Attribute (CA)

SOURCE	df	SS	MS	F	p
Condition	1	453	453	10.23	$<.01$
Sex	1	0	0	-	-
Interaction	1	80	80	1.80	-
Within	96	4250	44.27		
Total	99	4783			

for the Initial Labelling only, not being of significance for Total Labelling. Evidently the girls shift their methods of categorization after reflecting on stimuli.

It is in the Total Labelling category the Inquiry groups indicate some rather striking differences from the control children.

In Table 14 we find that in both the descriptive, part-whole (DPW) and Categorical Attribute (CA) SCST categories there are significant differences in Condition. Inspection of the means in Table 10 reveals that the Inquiry groups have the higher means in both categories. In first considering the descriptive, part-whole category, it might be pointed out that the Inquiry group merely provided a larger number of the same kind of DPW label. This seems reasonable since persons who use these labels pay attention to the details (parts) of stimuli. For instance in card 19 of the SCST (see Appendix C) persons who use these labels might write "These have eyes, hands, hair, arms, feet, shoes," and so on. The Inquiry child provided twice as many of these labels as did the Controls. This is evidence of a greater degree of fluency on the part of the one group. However, fluency alone is not the only criterion by which one may judge the potency of categorization behavior. Of even greater interest would be an exploration of the qualitative differences in the use of these labels. Certainly, if the Inquiry children merely "went down the line," so to speak, and listed as many overt stimulus parts as they could, this pattern would be evidenced in the percentage scores, where the fluency factor is controlled. On the other hand, if their reaction to the parts of stimulus situations were uniquely and qualitatively different, then some interesting results should be forthcoming. In Fig. 3 there is an analysis of this DPW labelling



1 - Parts, inanimate (includes parts of clothing and equipment)

2 - Parts, human (includes eyes, skin, arms, hair, hands, face)

3 - Parts, animal and vegetable (includes hooves, stems, trunks)

4 - Includes wood, plastic, metal

5 - Posture or position

6 - Wholes (includes uniforms, shells, coverings)

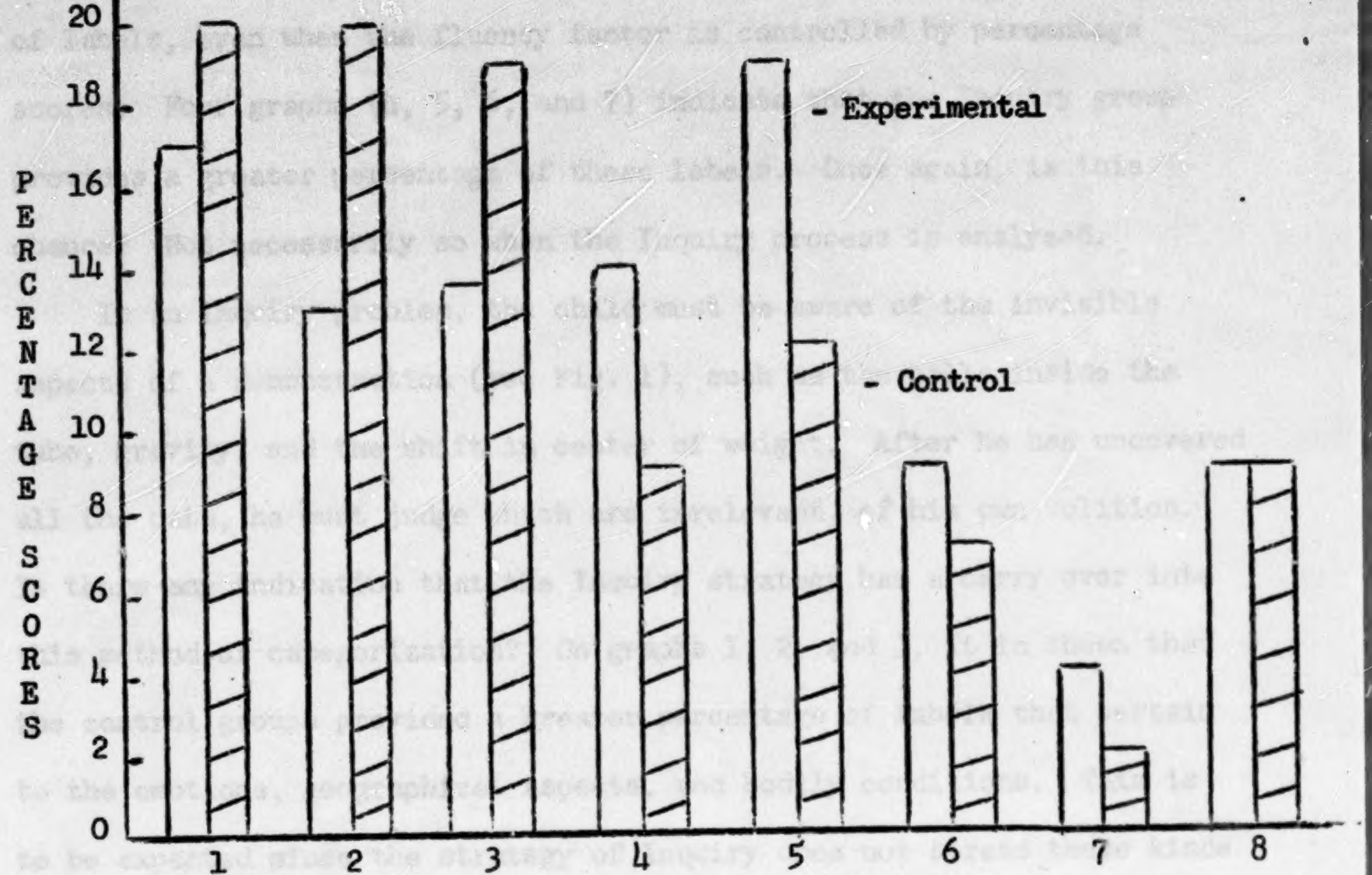
7 - Size and shape

8 - Shade (color, background)

Fig. 3 - Analysis of the Descriptive, Part-Whole Labelling for Sixth Grade Children

comparing the Inquiry and control groups. It must be kept in mind that these are percentage scores where fluency is controlled. We find that the Inquiry groups attend to the animate parts such as eyes and skin of pictures depicting human sorts a greater percentage of the time than the control groups. Again, the Inquiry children label vegetative and animal parts of stimuli more so than the control group. On the other hand, the control groups pay more attention to the parts of clothing and equipment, to the posture or position of bodies, to the size and shape of objects, and to the uniforms and coverings of objects. The Inquiry process encourages attention to detail. In an Inquiry problem (see Fig. 1 in chapter three) the child who is apt to ask, "Is there anything else?" is getting closer to the seemingly insignificant change that is at the heart of the solution to the problem, the shift in center of weight. It is this "set" to analyze an Inquiry problem situation that seems to be effecting changes in the styles of children. Worthy of note is that the Inquiry group shows a higher percentage of labels in those graphs (2 and 3) indicating close attention to detail, such as eyes or fingers. On the other hand, the control group focusses attention a greater percentage of the time on those labelling modes that do not require as close attention to detail, such as posture, size, or coverings (graphs 1, 5, 6, 7). Thus it appears that, in grade six, the Inquiry process has a significant effect on children in at least one method of labelling.

Again, the Inquiry children provided more of the categorical attribute (CA) labels than did the Control children. The issue is raised once more of the fluency factor. Are the Inquiry children merely providing a larger gross number of these labels? Or are the labels of a distinctly different quality than those used by controls? Inspection of



1 - Includes sad, angry, mad, happy

2 - Includes grow on vines, live in jungle, etc.

3 - Includes hurt, handicapped, sick

4 - Includes heavy, sharp, light, man-made

5 - includes good, bad, nourishing, delicious

6 - Includes blood, bones, backs

7 - Includes colors other than black and white

8 - Includes run, move, go

Fig. 4 - Analysis of the Categorical Attribute Selection for Sixth Grade Children

Fig. 4 shows that there are differences between the two groups in quality of labels, even when the fluency factor is controlled by percentage scores. Four graphs (4, 5, 6, and 7) indicate that the Inquiry group provides a greater percentage of these labels. Once again, is this chance? Not necessarily so when the Inquiry process is analyzed.

In an Inquiry problem, the child must be aware of the invisible aspects of a demonstration (see Fig. 1), such as the balls inside the tube, gravity, and the shift in center of weight. After he has uncovered all the data, he must judge which are irrelevant, of his own volition. Is there any indication that the Inquiry strategy has a carry over into this method of categorization? On graphs 1, 2, and 3, it is shown that the control groups provided a greater percentage of labels that pertain to the emotions, geographical aspects, and bodily conditions. This is to be expected since the strategy of Inquiry does not stress these kinds of cognitive responses. However, in graphs, 4, 5, 6, and 7 we find the Inquiry group produces a greater percentage of the kinds of labels referring to value judgements and inferences regarding physical attributes. Again, is this an accident? Not necessarily, for the Inquiry strategy is related to the behavioral aspects of these labelling procedures. For instance, graph 5 includes labels that indicate a value judgment has been employed. Mentioned above was the fact that the Inquiry strategy encourages autonomy on the part of the child: he must search, explore, and make value judgments constantly all on his own. It is felt, at this point, that this greater number of value-oriented labels by the Inquiry children is a reflection of the decision-making aspect of an individual's strategy. In graph 4 we find that the Inquiry child is more apt to make inferences about the physical attributes of objects, characteristics such as heavy or sharp. Again, there could be a direct connection between the Inquiry process and this stylistic preference. The child must be aware of the non-manifest conditions of objects, such as the weight of the balls inside the tube or the center of gravity, if he is to solve the problem. In graphs 6 and 7 we find more evidence of the relationship of the Inquiry process to categorization behavior. The Inquiry children provided a greater percentage of labels that go beyond the surface characteristics of stimuli. They are more apt to indicate internal details such as blood or bones and to make inferences about colors such as red or green. The latter is significant since the SCST pictures are in black and white. In Inquiry, too, the child has many experiences in going beyond the given; for instance, he must spot the balls *inside* the tube if he is to have problem-solving success.

Up to this point, the discussion has centered about differences between groups in their uses of the different cognitive style categories. Another method of assessing stylistic modes involves considering the kinds and amounts of shifting behavior between stimuli and the SCST categories. Thus far the Inquiry group has indicated that it not only is more fluent in its use of various kinds of verbal labels but its responses have a qualitative difference as well. Would there also be a tendency for the Inquiry child to be more flexible in his reaction to the stimuli of the SCST? Reference to Table 15 indicates that, indeed, there are differences in Condition. From the means in Table 10 it is shown that the Inquiry group possesses the highest number of shifting behavior scores in all three methods of tabulating this kind of behavior.

These results were expected since the Inquiry process encourages an exploratory attitude on the part of the child. The pupil must observe

TABLE 15

ANALYSIS OF VARIANCE OF SCST SHIFTING BEHAVIOR WITHIN GRADE SIX

Category Shifting Behavior Between Cards (FPCS)

SOURCE	df	SS	MS	F	p
Condition	1	92	92	6.17	<.01
Sex	1	3	3	-	-
Interaction	1	0	0	-	-
Within	96	1431	14.91		
Total	99	1526			

Stimulus Shifting Behavior (SS)

SOURCE	df	SS	MS	F	p
Condition	1	2144	2144	9.03	<.01
Sex	1	73	73	-	-
Interaction	1	13	13	-	-
Within	96	22784	237.33		
Total	99	25014			

Category Shifting Behavior Within Cards (CS)

SOURCE	df	SS	MS	F	p
Condition	1	208	208	5.80	<.05
Sex	1	35	35	-	-
Interaction	1	15	15	-	-
Within	96	3443	35.86		
Total	99	3701			

a demonstration at the start. Then his task is to analyze the situation for all relevant details. In order to do this, he must be constantly aware of the many different bits of evidence that are inherent in the demonstration (see Fig. 1). For example, he observes the tube changing its rate of swing and asks "If the tube were pulled back a different distance each time, would the swings change?" He then receives a no answer which tells him that elsewhere in the demonstration lies the evidence for which he is searching. Consequently, he must shift his attention from the manifest properties of the stimuli to the non-manifest--the goings-on inside the tube. Our feeling is that this tendency to shift attention in an Inquiry situation is related to the shifting behavior of styles of categorization.

Summary of the Findings

Science Concept Achievement

Perhaps the most remarkable finding here was that neither sex was superior to the other at any grade level in Science Concept Achievement. Another striking development was the significantly better achievement of the fifth graders in the Inquiry groups over the conventionally taught children in the same grade level, this in contrast to the complete lack of differences in this area for both the fourth and sixth graders.

Divergent Thinking (Creativity)

The results from this test instrument (FF) led us to suspect that the standardized achievement test scores were a strongly influential factor. In spite of the lack of significant results between groups in this area, we still suspect, from personal observation of the subjects, a potential relationship between creativity and Inquiry which we are continuing to seek in our further research.

Cognitive Styles in Categorization Behavior

In grade four, conventionally taught children provided more functional labels than the Inquiry children on Initial and Total Labelling. However, the Inquiry groups increased their Initial class-naming labels at the expense of the functional sort. Both of these findings indicated that within this grade level the first response made by children is a potent one.

In grade five, the evidence shows that girls in both methods of teaching are more adept at shifting their behavior than the boys. This finding could indicate that girls in this grade are changing to a different stage of thinking sooner than the boys.

Within grade six the Inquiry groups indicated qualitative as well as quantitative differences from the conventionally taught children. On Initial Labelling, as in grade four, the Inquiry children were less productive of functional labels. For Total Labelling in Descriptive, Part-Whole, Categorical Attribute, and all three types of shifting behavior, the Inquiry children were the superior group quantitatively in the production of labels. Also the quality of the labels used by the Inquiry groups was traceable to the elements stressed in this method of teaching--analysis, inferences regarding invisible characteristics, and flexibility of thought.

CHAPTER V

DEVELOPMENTAL TRENDS IN STYLES OF CATEGORIZATION: A CROSS-SECTIONAL ANALYSIS

Having already demonstrated some of the relationships between cognitive style and science concept achievement, we now move to focus on the area of cognitive style, with particular attention to the changes that occur related to age. In the previous discussion of each grade level, we sought relationships between teaching methods and style. However, we are aware of the fact that cognitive styles do not remain static but rather shift with age, some types of responses increasing, others remaining relatively stable, and others decreasing. In an earlier study, it was found, for example, that descriptive, part-whole responses tended to increase linearly with age for boys and girls regardless of the content involved (Sigel, 1965). In that same research, it was also discovered that categorical functional and class labelling (CN) tended also to increase with age, whereas relational contextual tended to be somewhat stable. In that study, however, the sorting behavior or the classifying behavior of the children was assessed through an individual task employing a series of discrete pictures where the child did not have to disengage any one or more pictures from a fixed context. In this current research the children were given three stimuli and told to pick out any two of them and label them accordingly. Actually the pictures were static, remaining in place and could not be manipulated. The difference in the experimental condition is primarily in the degree of manipulation, but the content and the mode of presentation were very similar.

In view of the fact that we have in this study children at three grade levels, fourth, fifth, and sixth, we have a chance to examine the consistency with which particular results are found and to relate them to previous research in the area. Before proceeding let us make it clear that this was not one of the deliberate intents of our study, however, we could not resist the temptation to analyze our data accordingly. It also facilitates our interpretation because it can explain the differential relationships obtained within grade levels as a function of the instability of the style variables over age.

Developmental change in particular orientations does not necessarily reflect an instability of the measure. As the child is changing and increasingly differentiates in his approach as well as increasing in his verbal ability and fluency, there is every reason to expect that his orientation to materials will vary from year to year. Consequently, the whole issue of reliability is approached from a different aspect, specifically we are concerned with the degree to which children show consistency over periods of time or transcend other sources of influence which may be operating as the child grows older. In other words, if the scores are consistent from one year to another, we may assume that the child is holding on to an orientation in spite of his increasing abilities in differentiation, analysis, fluency, and vocabulary. Thus the reliability of the test becomes important only within age levels, and has to be carefully interpreted as to its significance when we are talking across age levels.

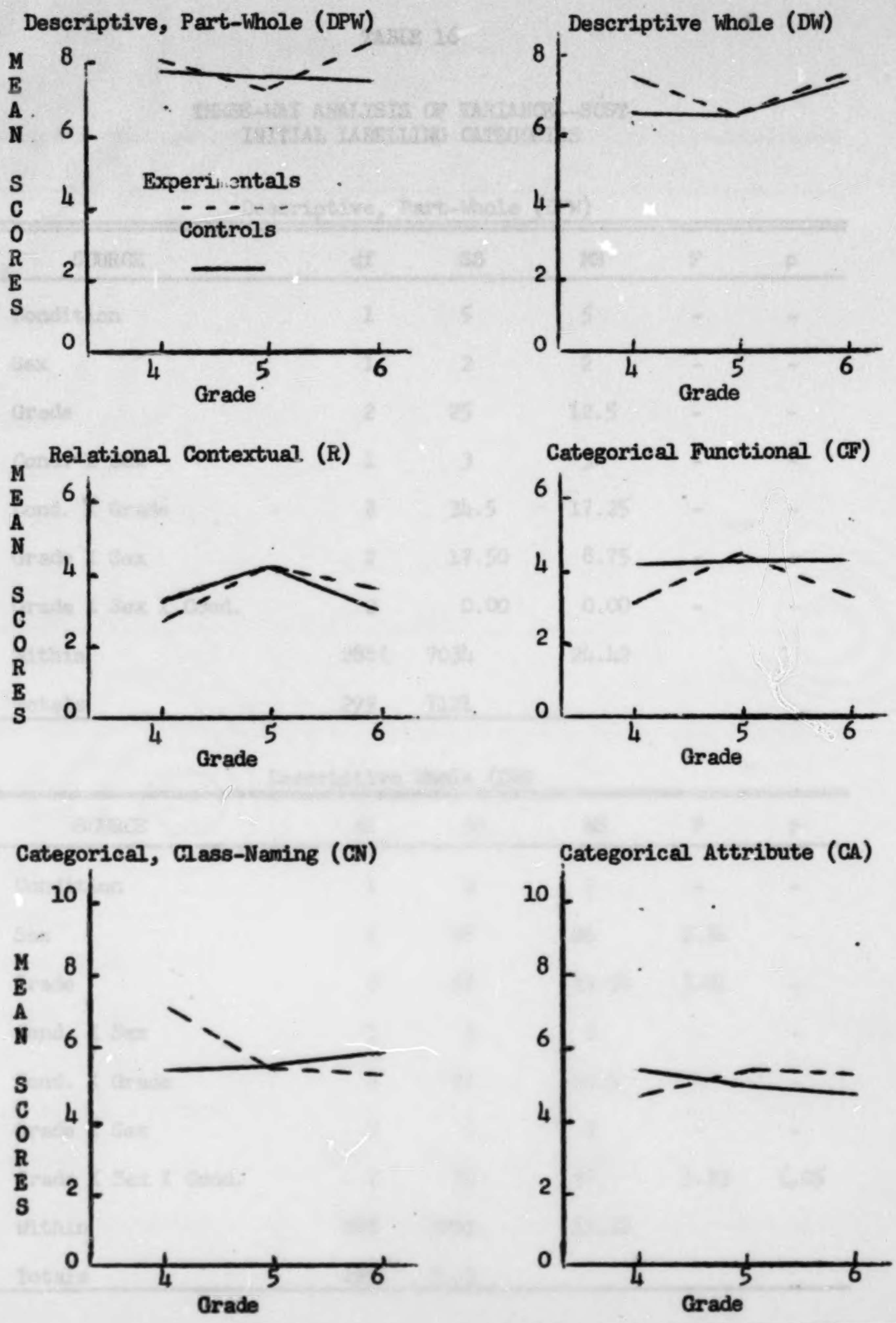
Developmental Trends of Cognitive Styles--Initial Labelling

If we work on the assumption that the very first label a child gives to an array is a reflection of his primary unelaborated preference we acquire data indicating the potency of particular orientations. On this assumption we analyzed the first labels given by children throughout their protocols and in Fig. 5 we have graphed the age trends.

Analyses of variance were carried out for each category involving triple interaction, Sex, Condition (experimental or control), and Grade. These triple interactions are shown in Tables 16 and 17. For the descriptive part-whole Initial Labelling, we find no significant differential between the Experimental and the Control, and no differences among the age groups. Descriptive whole, however, provides us with a significant interaction effect between Grade, Sex and Condition. For the categorical functional type labelling, we find a significant difference between the experimental and the control groups as well as Grade and Sex, and Grade, Sex, and Condition interaction. All the remaining categorical approaches we find S approaching but not reaching the significance level of .05 which was established for this study. The one exception was the interaction effect for Grade, Sex and Condition for the categorical attributive type of labelling.

The relational contextual labels tend to show some change with grade, but these changes do not reach a significant level. There is a slight increase from grades four to five; the plateau extends from five to six for the experimental groups, with a decline, although slight, for the Controls (see Fig. 5).

In summary, then, when we analyze the very first label the child uses as an index of his preferential classificatory response, we find consistent though not significant increases in the use of categorical types of responses.



Descriptive, Part-Whole (DPW)

Descriptive Whole (DW)

Relational Contextual (R)

Categorical Functional (CF)

Categorical, Class-Naming (CN)

Categorical Attribute (CA)

Fig. 5--SCST Initial Labelling Means between Grades for both Groups

TABLE 16

THREE-WAY ANALYSIS OF VARIANCE--SCST
INITIAL LABELLING CATEGORIES

Descriptive, Part-Whole (DPW)

SOURCE	df	SS	MS	F	p
Condition	1	5	5	-	-
Sex	1	2	2	-	-
Grade	2	25	12.5	-	-
Cond. X Sex	1	3	3	-	-
Cond. X Grade	2	34.5	17.25	-	-
Grade X Sex	2	17.50	8.75	-	-
Grade X Sex X Cond.	2	0.00	0.00	-	-
Within	288	7034	24.42		
Totals	299	7121			

Descriptive Whole (DW)

SOURCE	df	SS	MS	F	p
Condition	1	2	2	-	-
Sex	1	26	26	2.34	-
Grade	2	67	33.50	3.01	-
Cond. X Sex	1	3	3	-	-
Cond. X Grade	2	21	10.5	-	-
Grade X Sex	2	6	3	-	-
Grade X Sex X Cond.	2	74	37	3.33	$<.05$
Within	288	3203	11.12		
Totals	299	3402			

TABLE 16 (Continued)

Relational Contextual (R)

SOURCE	df	SS	MS	F	p
Condition	1	1	1	-	-
Sex	1	0	0	-	-
Grade	2	73	36.5	2.61	-
Cond. X Sex	1	1	1	-	-
Cond. X Grade	2	19	9.5	-	-
Grade X Sex	2	29	14.5	-	-
Grade X Sex X Cond.	2	5	2.5	-	-
Within	288	4035	14.01		
Totals	299	4163			

Categorical Functional (CF)

SOURCE	df	SS	MS	F	p
Condition	1	50	50	7.45	<.01
Sex	1	1	1	-	-
Grade	2	19	9.5	1.41	-
Cond. X Sex	1	1	1	-	-
Cond. X Grade	2	12	6	-	-
Grade X Sex	2	58	29	4.32	<.05
Grade X Sex X Cond.	2	46	23	3.43	<.05
Within	288	1933	6.71		
Totals	299	2120			

TABLE 16 (Continued)

Categorical, Class-Naming (CN)

SOURCE	df	SS	MS	F	p
Condition	1	14	14	-	-
Sex	1	2	2	-	-
Grade	2	42	21	1.46	-
Cond. X Sex	1	1	1	-	-
Cond. X Grade	2	78	39	2.71	-
Grade X Sex	2	35	17.5	1.22	-
Grade X Sex X Cond.	2	73	36.5	2.53	-
Within	288	4139	14.37		
Totals	299	4384			

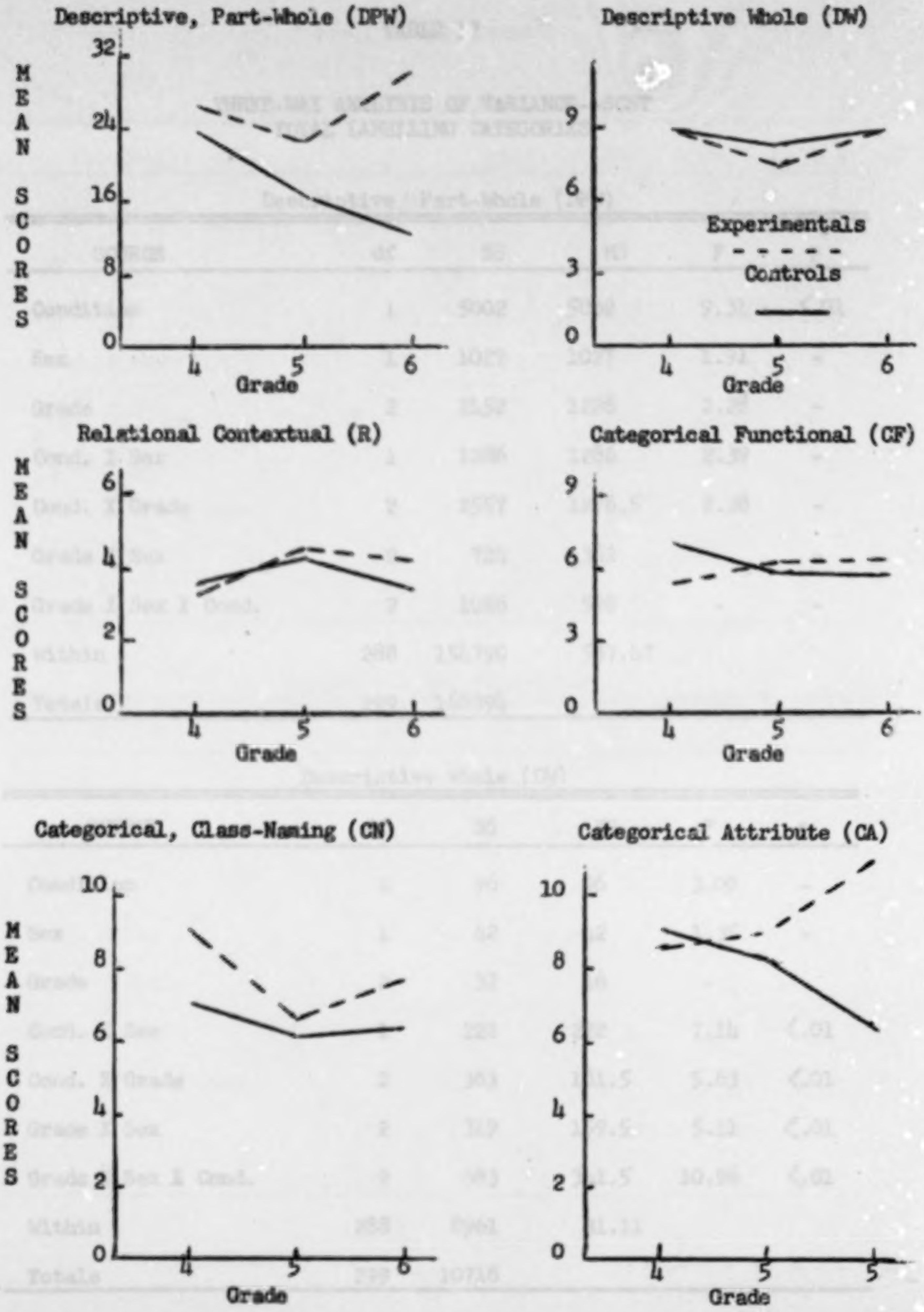
Categorical Attribute (CA)

SOURCE	df	SS	MS	F	p
Condition	1	0	0		
Sex	1	7	7	-	
Grade	2	4	2	-	
Cond. X Sex	1	17	17	1.99	-
Cond. X Grade	2	18	9	1.04	-
Grade X Sex	2	9	4.5	-	-
Grade X Sex X Cond.	2	52	26	3.05	$<.05$
Within	288	2451	8.51		
Totals	299	2558			

Results from Total Labelling

In this analysis we recorded all scorable units within our categories, which provided us with a more extensive picture of the kinds of labels used by the child. In Fig. 6 we have graphed these trends for all categories among the grade levels. Assuming that style is a broad approach, we are defining this score as a reflection of the child's elaborations and extensions of his classificatory behavior. On this basis, we found a significant difference between the experimental and control children in their use of descriptive, part-whole (DPW) labels. The trend shows a decrease between grades four and five and an increase between grades five and six among the Experimentals, whereas the Controls show a steady decrease in the use of part-whole responses (see Fig. 6). In effect, these results indicate that the Inquiry procedure has a tendency to maintain and increase the use of part-whole responses. This may well be due to the consistent requirement that the children isolate and identify relevant parts.

Descriptive global (DW) ratings do not show any significant differences between the Conditions or between Grade levels. The significant findings here relate to interaction effects between Grade, Sex, and experimental Condition. Table 10 which contains the means for all groups indicates that grade four control boys contribute less often to this interaction at that level, utilizing fewer labels of this type (DW) than the experimental boys and girls or the control girls. However, in grade five these results no longer hold, and we find that the experimental boys and the control girls are more similar to each other than to their like-sex counterparts in the other group. At grade six there seems to be no difference among the sub-groups in either experimental or control


Descriptive, Part-Whole (DPW)

Descriptive Whole (DW)

Relational Contextual (R)

Categorical Functional (CF)

Categorical, Class-Naming (CN)

Categorical Attribute (CA)

Fig. 6- SCST Total Labelling Means between Grades for both Groups

TABLE 17

THREE-WAY ANALYSIS OF VARIANCE--SCST TOTAL LABELLING CATEGORIES

Descriptive, Part-Whole (DPW)

SOURCE	df	SS	MS	F	p
Condition	1	5002	5002	9.31	<.01
Sex	1	1027	1027	1.91	-
Grade	2	2452	1226	2.28	-
Cond. X Sex	1	1286	1286	2.39	-
Cond. X Grade	2	2557	1278.5	2.38	-
Grade X Sex	2	724	362	-	-
Grade X Sex X Cond.	2	1056	528	-	-
Within	288	154790	537.47		
Totals	299	168894			

Descriptive Whole (DW)

SOURCE	df	SS	MS	F	p
Condition	1	96	96	3.09	-
Sex	1	42	42	1.35	-
Grade	2	32	16	-	-
Cond. X Sex	1	222	222	7.14	<.01
Cond. X Grade	2	363	181.5	5.83	<.01
Grade X Sex	2	319	159.5	5.11	<.01
Grade X Sex X Cond.	2	683	341.5	10.96	<.01
Within	288	8961	31.11		
Totals	299	10718			

TABLE 17 (Continued)

Relational Contextual (R)

SOURCE	df	SS	MS	F	p
Condition	1	7	7	-	-
Sex	1	0	0	-	-
Grade	2	55	27.5	2.24	-
Cond. X Sex	1	3	3	-	-
Cond. X Grade	2	24	12	-	-
Grade X Sex	2	32	16	1.31	-
Grade X Sex X Cond.	2	2	1	-	-
Within	288	3527	12.25		
Totals	299	3650			

Categorical Functional (CF)

SOURCE	df	SS	MS	F	p
Condition	1	15	15	-	-
Sex	1	32	32	1.78	-
Grade	2	1	.5	-	-
Cond. X Sex	1	35	35	1.94	-
Cond. X Grade	2	78	39	2.17	-
Grade X Sex	2	40	20	1.11	-
Grade X Sex X Cond.	2	6	3	-	-
Within	288	5185	18.003		
Totals	299	5392			

TABLE 17 (Continued)

Categorical, Class-Naming (CN)

SOURCE	df	SS	MS	F	p
Condition	1	265	265	9.13	<.01
Sex	1	13	13	-	-
Grade	2	208	104	3.58	<.05
Cond. X Sex	1	81	81	2.79	-
Cond. X Grade	2	113	56.5	1.94	-
Grade X Sex	2	19	9.5	-	-
Grade X Sex X Cond.	2	311	155.5	5.34	<.01
Within	288	8357	29.02		
Totals	299	9367			

Categorical Attribute (CA)

SOURCE	df	SS	MS	F	p
Condition	1	186	186	7.70	<.01
Sex	1	117	117	4.84	<.05
Grade	2	2	1	-	-
Cond. X Sex	1	123	123	5.09	<.05
Cond. X Grade	2	289	144.5	5.98	<.01
Grade X Sex	2	58	29	1.20	-
Grade X Sex X Cond.	2	11	5.5	-	-
Within	288	6956	24.15		
Totals	299	7742			

Condition. Thus, it seems that the interaction effect is due to the relatively infrequent use of the DW response by control boys in grade four and by both groups of girls in grade five. We shall have occasion to discuss these trends later.

Relational contextual responses show relatively low frequency and there are no significant differences as a function of any of the conditions in this study. Apparently, the use of such a response is not altered in any major way as a function of condition or age. Rather the level of this type of responsiveness tends to be consistent over the age span covered by this study, as indicated by the relatively slight variation in the means on Table 10.

Turning now to a discussion of the categorical inferential approach, (CF, CN and CA) we find in Total Labelling our most significant set of findings. Contrary to Initial Labelling, we find no difference as a function of Condition, Age, or Sex, in the use of categorical functional responses. A slight variation in mean scores exists, but is of no significance. We do find the use of categorical attribute significantly differentiated in Condition and Sex, but here also is an interaction effect between Grade and Condition, and Sex and Condition. At grade four, the experimental boys employ this approach less frequently than the experimental girls. In fact, the girls in the experimental group recorded inferential attributes (CA) more frequently than any children in the control groups or the boys in their own classes. This difference persists in the fifth grade where the relevant frequency is still highest for the experimental girls. By the sixth grade we find that the experimental girls still maintain their high proportion of CA responses with the experimental boys beginning to increase these responses, and the control groups seeming to decrease in their utilization of this approach. In other words, we can conclude that the experimental condition of Inquiry tends to influence girls' use of categorical attribute responses earlier than boys, and maintain this relatively high frequency compared to the boys in the experimental group, who are not very different from control groups until the sixth grade. Thus girls in the experimental groups tend to account for most of the significant findings indicated in this analysis.

Before we conclude that inferentiality is primarily a function of the girls' behavior, we will turn to a discussion of class labelling (CN), which is also an inferential type of response. Here we find significant differences in the use of categorical, class-naming (CN) as a function of grade. Specifically, in the table of means the grade four experimental boys utilize this orientation more frequently than any other group. In the fifth grade the frequency shifts to the girls who now are the most frequent users of class labelling. By grade six we find that the experimental boys regain their superiority followed by the girls in the experimental situation. The girls in the control group use this orientation least often.

The use, then, of class labelling varies as a function of age, showing deceleration trends between grades four and five, and acceleration trends between grades five and six. These trends, however, vary as a function of experimental condition and sex of the child.

Sex Difference

Implicit in these comments was the fact that the differences we find consistently seem to be related not only to our experimental conditions, but also to sex differences which we will proceed to discuss in detail. In figures 7-10, we have presented graphically the developmental trends for boys and girls in both the experimental and control groups for each of the six categories. Let us pay attention first to the boys.

Trends Among Boys For Initial Labelling

When we examine the initial responses of the boys in the three age groups, we find that there is relative stability for both the Experimentals and Controls in their use of part-whole labels as their initial response. Descriptive whole responses decrease between grades four and five for the experimental boys, but increase from five to six. The control boys show a slow linear accelerating trend so that by grade six the mean scores of the experimental and control groups are virtually identical (see Fig. 7 for category trends).

Relational contextual responses show a steady but insignificant increase between grades four and five and then a levelling off within the experimental groups, whereas the control groups remain fairly consistent. This is similar to results which have been reported elsewhere (Sigel 1965).

Categorical inferential types of responses (CF, CN, and CA) tend to show considerable change with age among the boys. Functional responses (CF) increase steadily for the experimental boys from the fourth to the fifth grades, and decelerate just as sharply, so that by the sixth grade experimental and control groups are quite the same. The control groups, however, show a slow, steady decelerating trend in the use of functional responses.

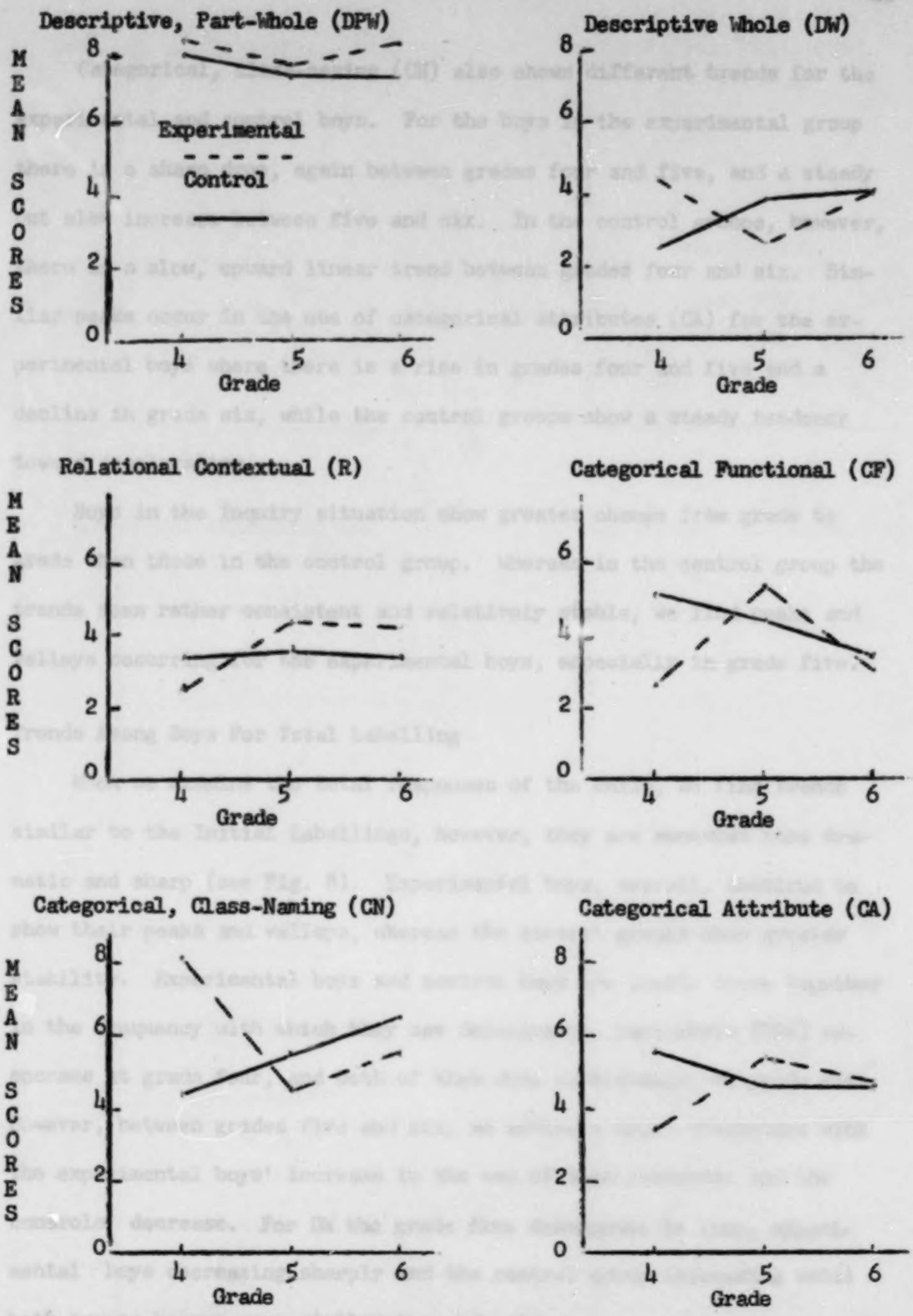


Fig. 7--SCST Initial Labelling Means between Grade Levels for Boys

Categorical, class-naming (CN) also shows different trends for the experimental and control boys. For the boys in the experimental group there is a sharp drop, again between grades four and five, and a steady but slow increase between five and six. In the control groups, however, there is a slow, upward linear trend between grades four and six. Similar peaks occur in the use of categorical attributes (CA) for the experimental boys where there is a rise in grades four and five and a decline in grade six, while the control groups show a steady tendency toward deceleration.

Boys in the Inquiry situation show greater change from grade to grade than those in the control group. Whereas in the control group the trends seem rather consistent and relatively stable, we find peaks and valleys occurring for the experimental boys, especially in grade five.

Trends Among Boys For Total Labelling

When we examine the total responses of the child, we find trends similar to the Initial Labellings, however, they are somewhat more dramatic and sharp (see Fig. 8). Experimental boys, overall, continue to show their peaks and valleys, whereas the control groups show greater stability. Experimental boys and control boys are pretty close together in the frequency with which they use descriptive, part-whole (DPW) responses at grade four, and both of them drop consistently at grade five. However, between grades five and six, we notice a sharp divergence with the experimental boys' increase in the use of such responses and the controls' decrease. For DW the grade five divergence is less, experimental boys decreasing sharply and the control group increasing until both groups become more similar by grade six.

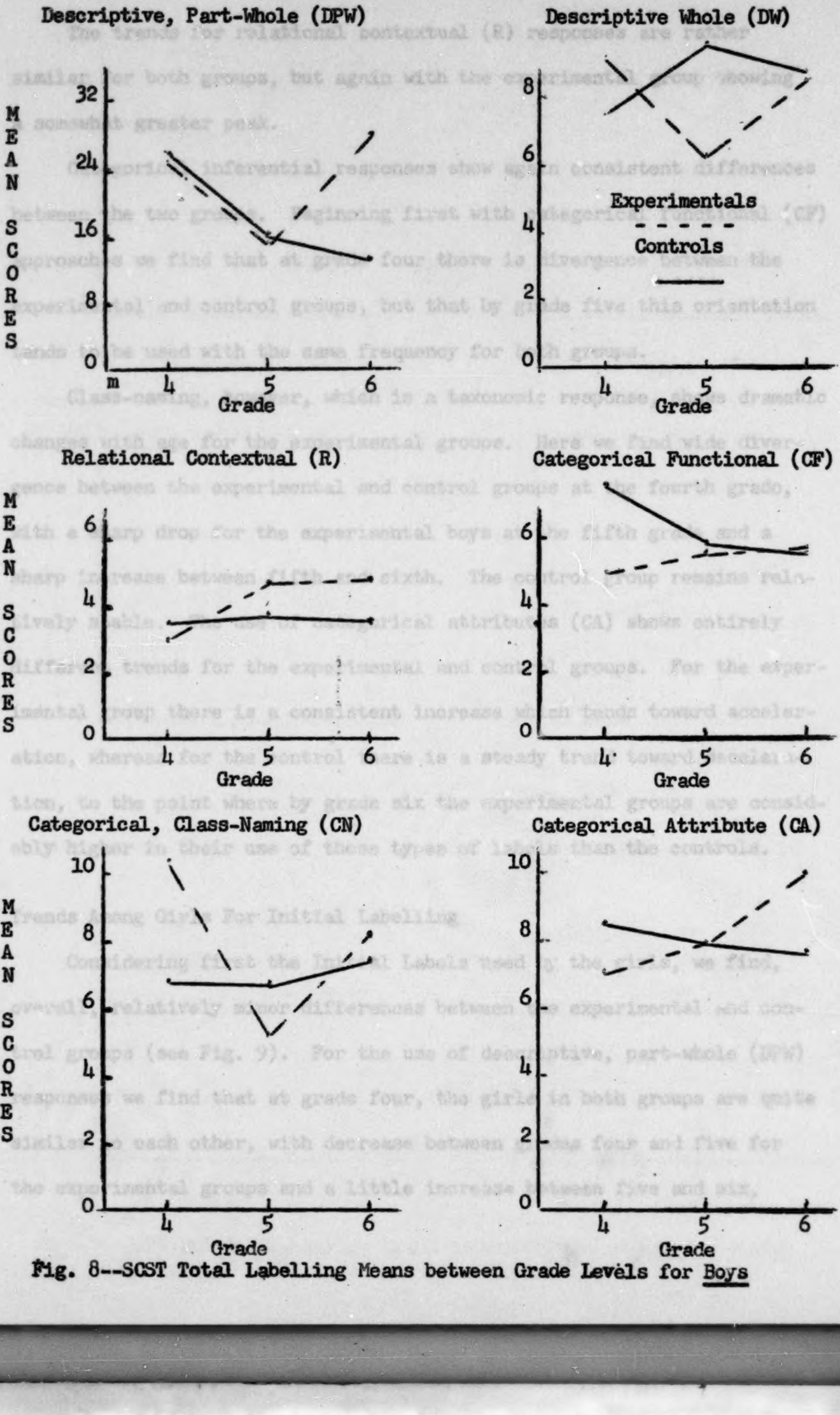


Fig. 8--SCST Total Labelling Means between Grade Levels for Boys

The trends for relational contextual (R) responses are rather similar for both groups, but again with the experimental group showing a somewhat greater peak.

Categorical inferential responses show again consistent differences between the two groups. Beginning first with categorical functional (CF) approaches we find that at grade four there is divergence between the experimental and control groups, but that by grade five this orientation tends to be used with the same frequency for both groups.

Class-naming, however, which is a taxonomic response, shows dramatic changes with age for the experimental groups. Here we find wide divergence between the experimental and control groups at the fourth grade, with a sharp drop for the experimental boys at the fifth grade and a sharp increase between fifth and sixth. The control group remains relatively stable. The use of categorical attributes (CA) shows entirely different trends for the experimental and control groups. For the experimental group there is a consistent increase which tends toward acceleration, whereas for the control there is a steady trend toward deceleration, to the point where by grade six the experimental groups are considably higher in their use of these types of labels than the controls.

Trends Among Girls For Initial Labelling

Considering first the Initial Labels used by the girls, we find, overall, relatively minor differences between the experimental and control groups (see Fig. 9). For the use of descriptive, part-whole (DPW) responses we find that at grade four, the girls in both groups are quite similar to each other, with decrease between grades four and five for the experimental groups and a little increase between five and six,

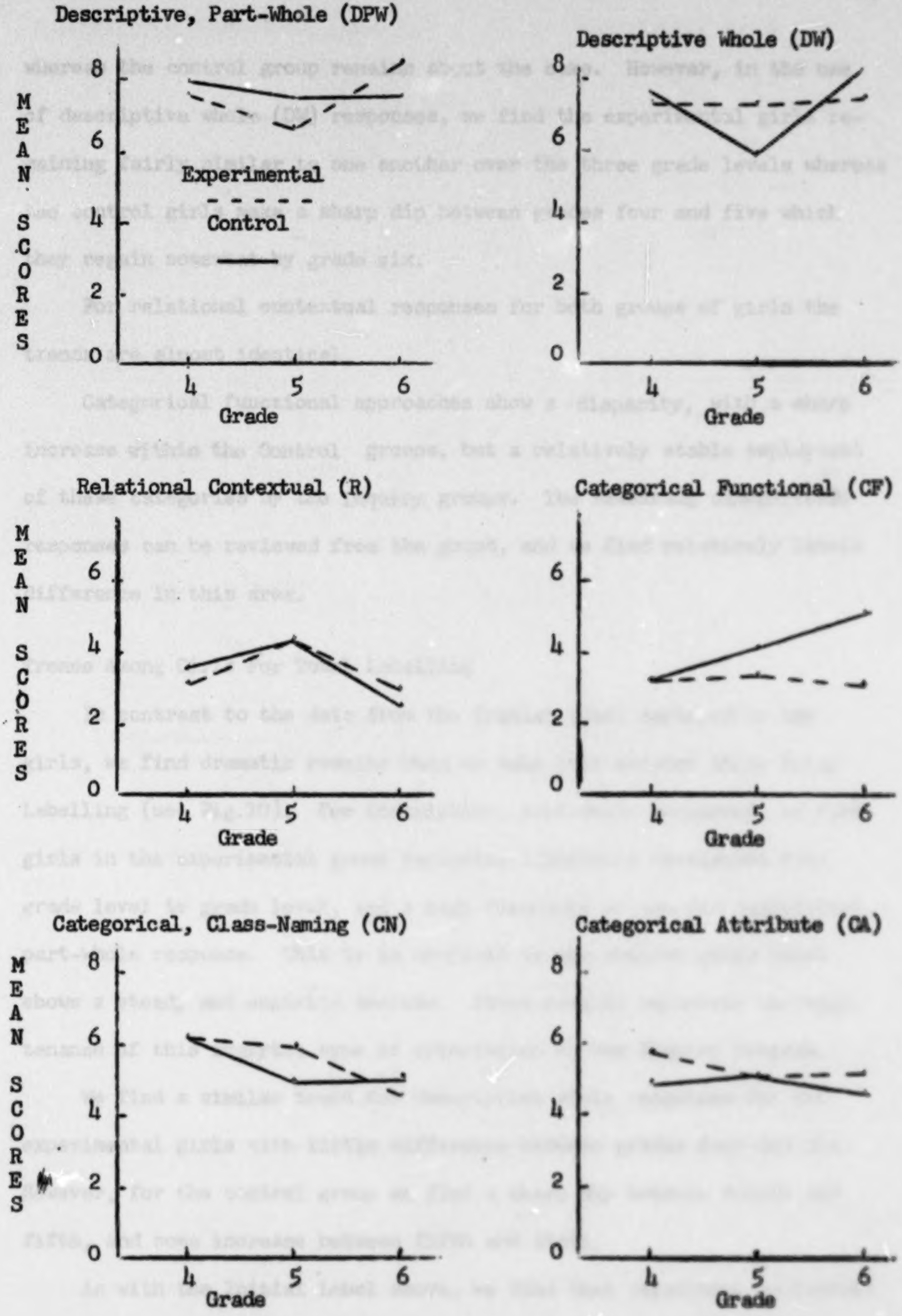


Fig. 9--SCST Initial Labelling Means between Grade Levels for Girls

whereas the control group remains about the same. However, in the use of descriptive whole (DW) responses, we find the experimental girls remaining fairly similar to one another over the three grade levels whereas the control girls make a sharp dip between grades four and five which they regain somewhat by grade six.

For relational contextual responses for both groups of girls the trends are almost identical.

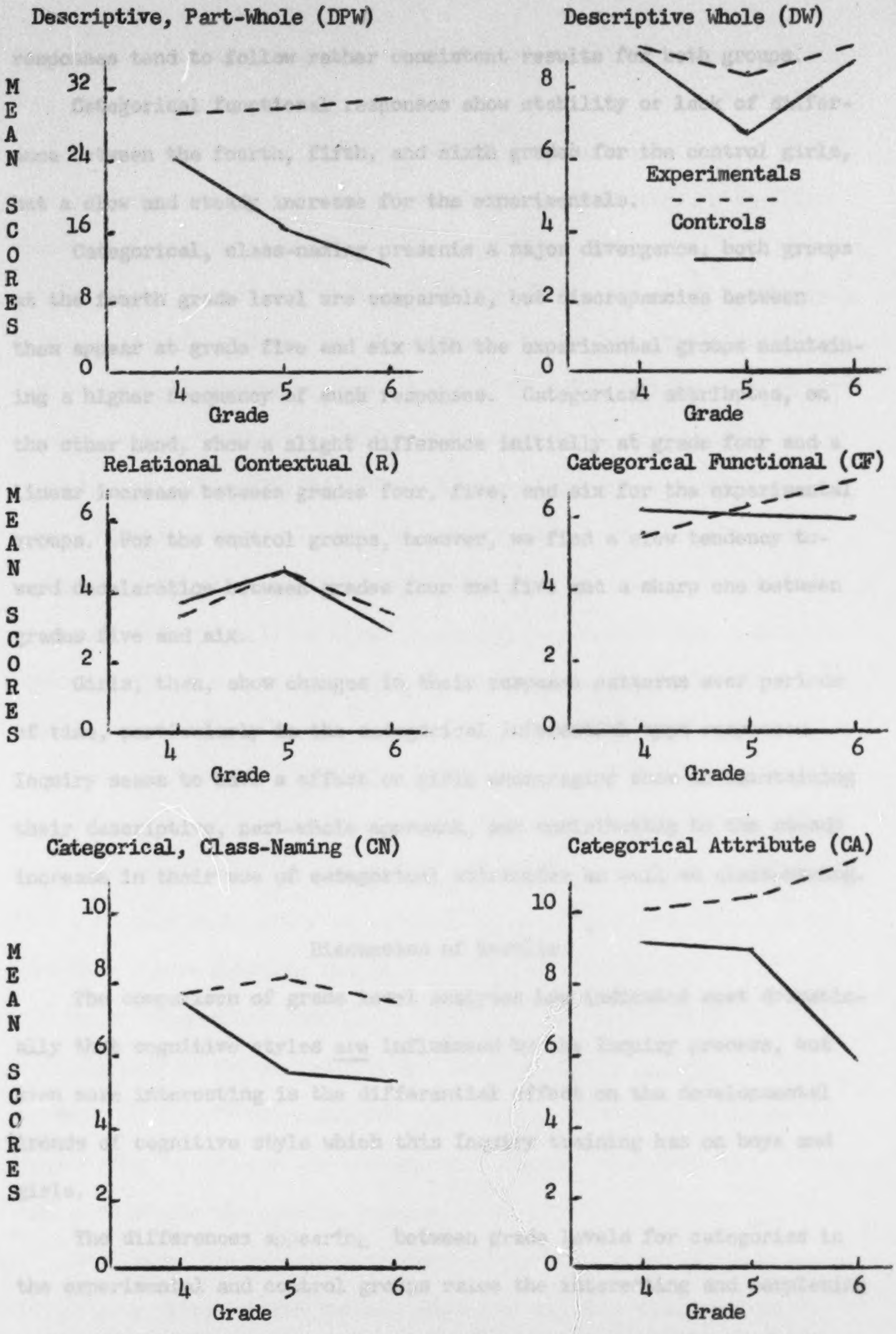
Categorical functional approaches show a disparity, with a sharp increase within the Control groups, but a relatively stable employment of these categories by the Inquiry groups. The remaining categorical responses can be reviewed from the graph, and we find relatively little difference in this area.

Trends Among Girls For Total Labelling

In contrast to the data from the Initial Label employed by the girls, we find dramatic results when we take into account their Total Labelling (see Fig.10). For descriptive, part-whole responses, we find girls in the experimental group remaining relatively consistent from grade level to grade level, and a high frequency of use for descriptive, part-whole response. This is in contrast to the control group which shows a steady and emphatic decline. These results reiterate the maintenance of this analytic type of orientation by the Inquiry program.

We find a similar trend for descriptive whole responses for the experimental girls with little difference between grades four and six. However, for the control group we find a sharp dip between fourth and fifth, and some increase between fifth and sixth.

As with the Initial Label score, we find that relational contextual



Descriptive, Part-Whole (DPW)

Descriptive Whole (DW)

Relational Contextual (R)

Categorical Functional (CF)

Categorical, Class-Naming (CN)

Categorical Attribute (CA)

Fig. 10--SCST Total Labelling Means between Grade Levels for Girls

responses tend to follow rather consistent results for both groups.

Categorical functional responses show stability or lack of difference between the fourth, fifth, and sixth grades for the control girls, but a slow and steady increase for the experimentals.

Categorical, class-naming presents a major divergence; both groups at the fourth grade level are comparable, but discrepancies between them appear at grade five and six with the experimental groups maintaining a higher frequency of such responses. Categorical attributes, on the other hand, show a slight difference initially at grade four and a linear increase between grades four, five, and six for the experimental groups. For the control groups, however, we find a slow tendency toward deceleration between grades four and five and a sharp one between grades five and six.

Girls, then, show changes in their response patterns over periods of time, particularly in the categorical inferential type responses. Inquiry seems to have a effect on girls encouraging them in maintaining their descriptive, part-whole approach, and contributing to the steady increase in their use of categorical attributes as well as class-naming.

Discussion of Results

The comparison of grade level analyses has indicated most dramatically that cognitive styles are influenced by the Inquiry process, but even more interesting is the differential effect on the developmental trends of cognitive style which this Inquiry training has on boys and girls.

The differences appearing between grade levels for categories in the experimental and control groups raise the interesting and perplexing question of how to explain the fact that girls and boys respond differently to the Inquiry process.

As will be recalled from our initial discussions in chapter three, we raised the question of the potential impact of Inquiry on cognitive structure by virtue of the requirements of the Inquiry process. Our discussion there pointed out that the demands of Inquiry required attention to detail and ability to make inferences. To be sure, these changes in such functions actually occurred, but why it should affect girls differently from boys cannot be answered from our data, and whatever we might have to say about it would be highly speculative. Is there any reason to expect boys and girls to assimilate and adapt to a common learning experience so differently, contingent upon the age level in question? For example, we find between grades descriptive, part-whole responses show little change among girls in the experimental group, but show dramatic changes for the experimental boys between the grades four and five. Although by the sixth grade both are using such orientations with comparable frequency, this is not true at the fifth grade level. Inspecting the graphs for comparison of the boys' and girls' trends, we find a picture that defies explanation at the moment. We may have to move into a more detailed analysis of the cognitive structure changes that occur between boys and girls, with the possibility that girls' sensitivities to the environment and assimilation of material evolve not only at a different rate, but also with a qualitative difference. There certainly is room for considerable inquiry to uncover the variables that account for the effects observed here.

What makes the picture more perplexing, and, on the other hand, offers some direction for further study, is the fact that even in the control groups differences between the sexes manifest themselves, so that not all cognitive style differences apparent between boys and girls can be attributed to the Inquiry process. In other words, we have two phenomena operating here: (1) there are sex differences in cognitive style that seem to occur as a function of the Inquiry process, and (2) there are differences in the degree to which boys and girls respond to and are influenced by experience generally. This allows us to make the one general statement that the cognitive style development for boys and for girls varies as a function of age, and our next problem is to research the specific determinants of this.

These results are not completely consistent with those reported by Sigel in 1961 and 1965, where sex differences in the frequency of category employment were not significant. His initial research was based on longitudinal analyses which showed that there were similar trends in the use of descriptive, part-whole responses for boys and girls with a steady increase occurring. The difference between the current results and the previous ones may be attributable to the unusual educational experience of one group. Too often in developmental research the role of educational experiences on the rate and direction of growth is not considered. Thus, before we conclude that these results are in fact contradictory we need to take into account the conditions of the assessment.

CHAPTER VI

CONCLUSIONS, RECOMMENDATIONS, AND SUMMARY

The speed with which today's world is moving socially and technologically is a breath-taking phenomenon. The changes on our planet, many of which are quite welcome, have undeniably created a few problems. For instance computers, having taken over the burdensome arithmetical details that formerly were the domain of clerical help, now require a substantial number of people adept at the problem-solving process of computer programming. And so today there is an ever increasing need for more problem-solvers among the individuals released by our educational institutions. Today's automation demands all the creative ability and imagination of which the individual is capable. In the social realm, too, there are many challenging areas. All over the world groups large and small are verbalizing their goals--and problems. The different cultures scattered about our globe represent such a variety of ideational beliefs that there is a pressing need for greater understandings of the different social and economic principles underlying the actions of these nations. In great demand is the individual who not only understands his own point of view but is able to shift his thinking so that he comprehends the other person's unique vantage point. If what we have seen in the Inquiry program is an indication, these potentialities of flexible and intuitive thinking can be developed and flourish in an educational setting geared specifically to the encouragement of this type of intellective activity.

First off, some of the findings of the current project reinforce thinking already prevalent in educational circles and provide additional insight into new ideas. It has been common knowledge that sex differences are factors with which one must deal when planning a curriculum. As a result of research in this area of child development, some pioneer work has been started in an effort to accomodate into the curriculum what we know about the sexes. The findings of this project suggest that these efforts should be expanded. For instance, our data indicate that girls hold an edge over the boys in their preference for making inferences about the invisible attributes of stimuli, and they shift attention from one stimulus to another more frequently than do boys. However, the data also show that, by the time they reach grade six, the Inquiry process has helped to close the gap between the sexes to a considerable extent with regard to these differences. The boys in the Inquiry program seem to be affected by this teaching method which stresses verbal behavior. This implies that our curriculum procedures need not remain static, with one sex continually exhibiting superiority over the other in certain cognitive activities. The Inquiry process seems to provide a climate for development of some sorely needed intellective skills among the boys and at the same time continues to stimulate the girls in their problem-solving activities.

The standardized measures of achievement used in today's schools provide the major source of determining the abilities of students in many school systems. These instruments apparently have been designed with achievement of subject matter in mind for there is a high correlation between these so-called I. Q. scores and those scores of an academic nature. In addition, these testing techniques have a high relationship to the socio-economic status of the individual. Although there is a place for such methods of evaluation, it is our contention that more definitive ways of predicting the behavior of the child are needed if the latent abilities of all children are to be brought to fruition. The findings in this investigation suggest that just such a first step has already been taken.

As a plant must unfurl of its own accord in nature, can the individual indicate his needs or potential more completely by means of a task through which the flow of conceptual thought is outward from himself? An underlying weaknesses of standardized achievement tests is that they are standardized, imposing on each person specific criteria by which he is measured. Not so with the SCST, in which the child is instructed that there are no "right's" or "wrong's." This tends to give each child the opportunity to reveal his more natural individual mode of behavior. Under these instructions the child indicates on the SCST much of his behavioral pattern and possibly how he modifies it. This individual processing of information that leads to "learning" may be a vital factor in any new educational developments. With information of this type available, a teacher would be in position to assist a child in re-vamping his mental operations, or to provide him with a maximum of his own type of processable data for the most efficient and most permanent learning. The Inquiry process encourages an exploratory attitude on the part of the child, and the searching process is his own, resulting from questions generated within his own cognitive domain. First, a teacher has the unique vantage point of observing the student through the verbal windows of each child's own experiences. Natural strengths and weaknesses can be fairly easily detected for future cognitive therapy. Second, the elements of Inquiry are related to identifiable modes of stylistic behavior. Knowing this, a teacher can, for instance, encourage a child who has a tendency to deal primarily with the overt and the concrete to shift some of his attention to the invisible, attributive aspects of stimuli. Our data suggest that these activities are not only plausible, but possible.

The stars in the heaven seem so far away. There was a time when people thought that there were only a few thousands of these twinkling dots of light. Now, by means of such pieces of giant apparatus as the Hale telescope we can detect uncounted millions of them. We suspect that bigger and better instruments will uncover even more celestial activities. In the findings of our study, we sense a parallel. If the cognitive style task had not been used in this investigation, one might have concluded that the Inquiry process had little significant effect on the conceptual activities of children. Then this research would have been like the person without a telescope who could see only a few shining objects in the sky. However, Suchman hinted that something else seemed to be developing besides the obvious overt verbal ability to ask questions in children exposed to Inquiry strategy. None of his testing instruments was able to substantiate his hunch.

In this investigation, however, the use of the styles of categorization task has indicated some interesting quantitative and qualitative cognitive activities of children. For instance, in grade six, there was no obvious difference between the Inquiry and Control groups in science concept achievement. The science test (CET) apparently was not capable of determining the extent to which Inquiry strategy was affecting these children. However, the styles of categorization task (SCST) showed that the conceptual processes of the Inquiry children were significantly different from conventionally taught students. The important aspect of these findings was not so much that there were differences but that stylistic preferences of the Inquiry children were definitely related to the problem-solving strategy used in the science lessons. Through the use of an instrument that was sensitive to the perceptual and conceptual activities of children, a wealth of new information is available that would probably still be beyond our grasp. It is recommended that further research probing into the cognitive domain be done with testing tools that can, like the scientific instruments used in space exploration, offer glimpses past the obvious and into the unique mental workings of the human mind.

Perhaps the most significant fact to come out of this research is that the Inquiry process does encourage and develop an exploratory attitude on the part of the learner that leads him beyond the overt perceptual phenomena inherent in our physical world. This is not to say that the factual details so necessary for an analytical mode have been neglected. Indeed, the strategy of Inquiry makes children much more attentive to the fine points in a problem situation. What is highly significant is the intuitive mode of thought that the Inquiry strategy brings out in children. This process is exemplified by the investigation of invisible attributes such as the center of weight or the pressure of air inferred in problem situations. In order to make these kinds of implications, a person must have a "set" to seek and to search--to go beyond the given. It is this kind of cognitive activity that is of great demand in this era. The products of our technology are most efficient at relieving us of many menial tasks. The very existence of these engineering marvels has created a greater than ever demand for people who can use them in constructive ways. Consider a jet airliner for a moment. These machines are truly marvelous, requiring a highly skilled person to pilot them. Yet, their great speed, although an asset, has created problems with reference to the vertical up and down-drafts in turbulent air. This problem will be solved by a person capable of extending his thinking about the relationships of temperatures and pressures and other invisible attributes. This kind of individual is in great shortage today, principally because intuitive thinking has not been emphasized in our educational systems. Since the Inquiry process places a premium on this mode of behavior, it is highly relevant to the trends developing in our educational systems.

Recommendations For Further Research

The findings of this investigation suggest emphatically several areas of research that need illumination. First of all, one obvious need is the expansion and refinement of the Inquiry Science curriculum as outlined in this report, complete with an appropriate testing program. Since this type of Inquiry process has demonstrated its potential as a teaching method in elementary school science, it is suggested that efforts be made to adapt this approach to other subject areas, such as mathematics and social studies. In both of these areas the broad, basic fundamentals are frequently ignored in favor of precision in calculation or exactness in repeating knowledgeable answers. Will a child who has "discovered" for himself that the three angles of a triangle sum up to 180° do more than remember that answer for the test? And if he forgets it, will he be able to reconstruct his discovery and quite easily apply the principle involved in a new situation? Will a child who has "discovered" the inherent essentials of a newly born government be more likely to acquire the concepts involved than the child who has memorized a chart of the branches of our own government? We could well afford to assess Inquiry and its effects in these and other fields and of course this would entail curriculum development to bring order into the program.

Separate and apart from curriculum, another area of research that should prove fruitful is a study of the longitudinal effect of the Inquiry process on a sampling of children. Our results have indicated that Inquiry children are affected cognitively in different ways at different grade levels. However, different subjects were used at each grade level. We have thus far no accurate way of determining whether our results are really indicative of what happens to a given child as he passes from one grade level to another. However one would surmise on the basis of these data that the individual may be affected in a manner similar to the group effect. It seems as though the direction of movement should be toward a longitudinal study with its chief purpose the assessment of cognitive changes that may take place in individual children over the three year period of Inquiry programming.

Another research area that presents itself is the assessment of the degree to which the child exposed to Inquiry in one field generalizes the approach into other fields of knowledge. Hopefully, teachers could accept such question-asking children in conventional teaching programs. If these two conditions prevail, that is, teacher acceptance of children exposed to Inquiry and the child's application of his newly acquired problem-solving strategy, then it might be necessary only to provide the child with Inquiry experiences in one subject matter area. Since he will have been taught a technique for solving problems, he will be able to proceed on his own in any area.

Summary

Three hundred Detroit, Michigan Public School children in grades four, five and six were taught a series of fifteen science concepts, five at each grade level. Half of them were taught using Inquiry, a specific discovery approach initiated by J. R. Suchman, and refined by Norval Scott, and the other half were taught by conventional methods. At the end of the school year all the subjects were given a science concept achievement test (CET), a creativity task (FF), and a cognitive styles task (SCST).

The data were analyzed to compare the effect of the teaching method on Science Concept Achievement, Divergent Thinking (Creativity), and Cognitive Styles and to discover any sex differences as a result of the variables of this research. The effort was made also to detect any developmental trends in the cognitive functions of the children.

The data indicate a number of significant differences:

1. For Science Concept Achievement, there was one difference attributable to teaching methods. In grade five the Inquiry children achieved science concepts better than children taught by the conventional approach. For the other two grades there were striking similarities in the groups in Science Concept Achievement. 5

2. For Divergent Thinking, there were no apparent differences between any of the groups.

3. For Styles of Categorization, in grade four, the Inquiry children were significantly less inclined to categorize pictures of familiar objects and people on the basis of use, or function than the Controls. In grade five, the Styles of Categorization that were used depended on the Sex and Teaching method. No significant differences were found

between teaching conditions. Within grade six the Inquiry groups used fewer categorical functional labels than the Controls. The Inquiry groups also classified familiar items significantly more often than the Controls on the basis of manifest details and inferred attributes. Finally we found that the Inquiry groups were more flexible in their classification behavior than the Controls.

4. For Sex Differences, boys and girls were differentially influenced by the same teaching process. Girls showed changes in their response patterns, particularily in their increased use of inferential type responses. Inquiry strategy seems to encourage girls to attend to detail from grade to grade and also to increase in their inferences regarding attributes. Boys, in contrast to girls, show greater variability over the three-year span in their attention to detail and use of classifying labels.

FOOTNOTES

1. The assumption that this represents a cross section of the schools is based on the fact that they are located in a variety of districts ranging in socio-economic status from lower-lower, to upper-middle.

2. An attempt was made by Scott (1962) to validate the construct validity of this type of test. First, fifty subjects from grades 5, 6, and 7 in nine Detroit Public Schools were selected on the basis of their scores on two of the test problems. Half of the children were high achievers; that is, they had successfully answered all the sections on a particular problem correctly. The remaining children were low achievers, missing all the answers in the same problem sections. Then, each teacher interviewed the subjects who had been selected from her school, using a science demonstration that represented the same concept as that used in the selection process. After the interview the teacher judged whether the child was a high or a low achiever on that concept. These results were compiled and the data indicated that the teachers' judgment and the test scores were in agreement 66% of the time. This is the only known attempt to assess the validity of this kind of test.

3. Bartlett's Test, a test for homogeneity of variances, was applied to the data in question. On the one hand in grade five the results indicated that the variances were homogeneous for inductive reasoning but not for cognitive style. On the other hand, in grade six precisely the reverse was true.

4. Only the tables containing significant results ($p < .05$) are included in the report. Copies of the remaining tables are available on request for within grade level data.

5. In view of the fact that the Science Concepts studied by the children in this project included not only the Physical Sciences but also Geology, Chemistry, and Biology, the title of this project is not entirely representative of the area studied.

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APPENDICES

A. Science Concept Achievement Test (CET)

B. Sample Science Lessons

C. Cognitive Styles in Categorization Behavior Task (SCST)

D. Creativity Task (FF)

APPENDIX A

CET Test Instructions and Sample Problem

Problems from each CET Test

SCIENCE CONCEPT PROBLEMS BOOKLET

Information and Direction for Administration

The CET is a test which is designed to measure knowledge and comprehension of a set of science concepts. The test is oriented towards assessing the child's grasp of the cause - effect relationships inherent in a given science concept. There are four areas that the test samples for each concept:

1. Given a cause, search for a related effect.
2. Given an effect, search for a related cause.
3. Given examples of causes and effects, place those together that are related.
4. Integrating the preceding three areas into an accurate explanation of the science relationships involved in the problem.

The test consists of ten problems. Each problem poses four questions which test the child's understanding of the above-mentioned four areas.

Pretest Preparation

Before administering the test, you will need to check the following points:

1. Make sure that you have enough booklets and answer sheets for all the students taking the test. Keep an additional copy of the test and answer sheet for your use while demonstrating the test procedures.

2. Insert an answer sheet into each booklet at the Sample Problem page before distributing the tests.

3. The test is a progressive one and revealing information is given in each successive answer section. Therefore, the children may not change their answers once they have marked a choice on the answer sheet. To assure this, provide each child with a pencil that has had its eraser tip broken off. Have a supply of extra pencils available to avoid delays.

4. Seating accommodations should provide for maximum comfort and separation.

5. Since this is an untimed test, it is difficult to predict the exact length of time that will be needed for the entire group to finish. Approximately forty minutes should be sufficient for a sixth or seventh grade group. Fourth or fifth grade sections may have to finish the test at a second science period.

6. Specific instructions for the administering of the CET are provided and should be used. THE EXAMINER SHOULD BE THOROUGHLY FAMILIAR WITH THE TEST INSTRUCTIONS BEFORE HE ATTEMPTS TO GIVE THE TEST.

Directions for Administering the CET

Instructions which should be read to the children are enclosed in boxes. Other instructions refer to procedures involved in the test situation.

When the children are seated, distribute the pencils first and then the CET booklets with the enclosed answer sheets. Instruct the pupils to fill in the answer sheet. When this task is done, tell the children to move their answer sheets to one side. Then say:

> This is an interesting booklet about science problems. You will be given some information about a set of science experiments. With this information you will try to figure out what the results of each experiment will be and why they will be that way. Open your booklet to the first page and we shall work the Sample Problem together. Notice that, on the left-hand page, there is a picture and some information. The right-hand page has four flaps. I will show you what to do with these flaps soon. First, look at the information on the left-hand page. There is a picture of a steel ball hanging on a string. The information given is:
> A is a steel ball hanging on a string from hook B. A is free to swing back and forth.

Pause

> Now look at the page on the right. There are four flaps. The top flap is Part A of the Sample Problem. The next flap is Part B. The third flap is Part C. And the bottom flap is Part D.
> You must always answer Part A before looking at Part B and answer Part B before looking at Part C and answer Part C before looking at Part D. Now fold back the top flap.

Pause

Allow time for the children to look at the top section. Check that they unfold the flap properly.

> You are now looking at Part A of the Sample Problem.
> The question in this Part is:
> If the string is shortened, what will happen?
> You are to choose one of the three answers provided.

Answer 1 states that "the ball will swing faster." This might be the right answer but we must check all the answers in case there is a better one. Answer 2 says that "the ball will swing slower." This could be right. But let us check all the answers first. Answer 3 states that "the results will be the same." This hardly seems likely since the string has been shortened. Answer 1 is correct answer since a pendulum will swing faster when the string is shortened. Take your answer sheet and find the space for answers to the Sample Problem. It is located in the box near the top of your answer sheet.

Indicate this space.

Find Sample Problem, Part A, and place an X on number 1 because answer 1 is the best answer.

Check as the examinees do this.

Now fold the top flap back the way it was when you first saw it. Fold back the next flap. This should be Part B. The question for Part B is: In order for the ball to swing faster, what could you do?

1. Make the ball heavier.
2. Start the swing higher up.
3. Make the string longer.
4. Make the string shorter.

Study these answers, choose the one you think is best, and cross out the number of that answer on your answer sheet, Sample Problem, Part B.

Allow time for students to record answers.

You should have placed an X on number 4. Number 4 is the best answer because, as you remember in Part A, we said that the way to make a pendulum swing faster is to shorten the string.

Pause

Now fold the flap to Part B back the way you found it. Fold back the next flap. This should be Part C. The question in this Part is:

Which answer has the two ideas that go together best?

1. heavy ball -- fast swing
2. heavy ball -- slow swing
3. long string -- fast swing
4. long string -- slow swing

Which is the correct answer?

Wait for children to record answers.

Yes, answer 4 is right. Remember that the length of string, and not the size of the weight, goes together with the speed of the swing.

Pause

Now fold the flap to Part C back the way you found it. Fold back the last flap. This should be Part D. The question in this Part is: Which answer best explains your answers to Parts A, B, and C?

1. As a ball is made heavier, it swings slower.
2. As a ball is made lighter, it swings slower.
3. As the string is shortened, a ball swings faster.
4. As the string is shortened, a ball swings slower.

Which is the correct answer?

Wait for students to record answers.

Yes, answer 3 is right. You should have placed an X on number 3 on your answer sheet for Sample Problem, Part D. Put your pencils down now and listen.

Pause

You will work all the problems exactly as we did this one. Study the experiments and read the directions carefully. Think about your answer before you mark the answer sheet because you may not change your answer after you have recorded it. Be sure you put your answers on the right places on your answer sheet. Always answer Part A of a Problem before Part B, Part B before Part C, and Part C before Part D. You will have time to complete all the problems. When you have finished, you may check that you have answered all the questions and that you have recorded your answers. correctly. Then close your Concept booklet and place your answer sheet on top of it.
Don't mark the test booklet as it may be used again.
Mark only your answer sheet. Remember to fold the flaps to each Part back the way you found them.
Now, do you have any questions?

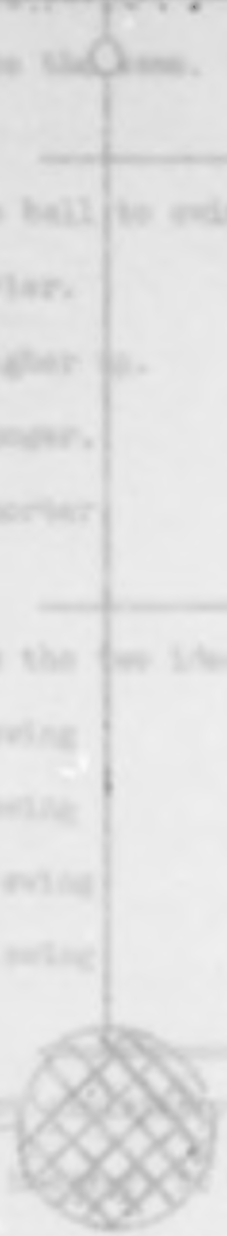
Allow time for questions -- if any.

You may begin.

During the first few minutes of the test period, circulate among the students, checking that they are using the test booklets and answer sheets correctly and that the proper information appears at the top of the answer sheets. As soon as a student is finished, pick up his test booklet and answer sheet. Be sure that those who finish early do not communicate with others who are taking the test. It is suggested that some sort of reading, or individual game, be made available for those pupils who finish early.

Do not discuss the test with the children at any time afterwards since the same test will be given at the conclusion of the Inquiry Program.

[illegible]



Part A -- If the string is shortened, what will happen?

1. The ball will swing faster.

[redacted]

3. The result will be the same.

Part B -- In order for the ball to swing faster, what could you do?

1. Make the ball heavier.
2. Start the swing higher up.
3. Make the string longer.
4. Make the string shorter.

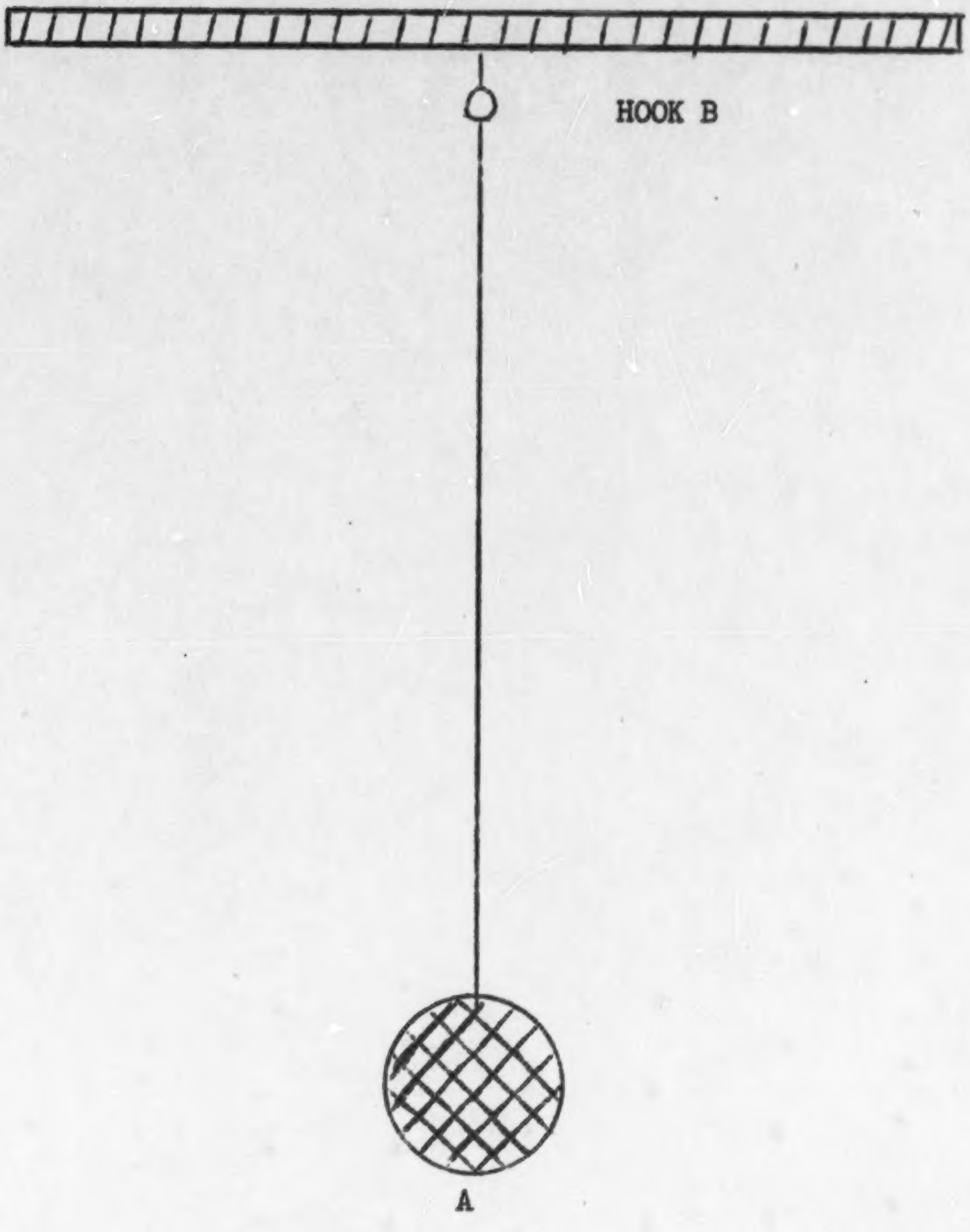
Part C -- Which answer has the two ideas that go together best?

1. heavy ball--fast swing
2. heavy ball--slow swing
3. long string--fast swing
4. long string--slow swing

Part D -- Which answer best [illegible] your choices to Parts A, B, and C?

1. As a ball is made heavier, it swings slower.
2. As a ball is made lighter, it swings slower.
3. As the string is shortened, a ball swings faster.
4. As the string is shortened, a ball swings slower.

SAMPLE PROBLEM



A is a steel ball hanging on a string from hook B. A is free to swing back and forth.

SAMPLE PROBLEM

Part A -- If the string is shortened, what will happen?

1. The ball will swing faster.
2. The ball will swing slower.
3. The results will be the same.

Part B -- In order for the ball to swing faster, what could you do?

1. Make the ball heavier.
2. Start the swing higher up.
3. Make the string longer.
4. Make the string shorter.

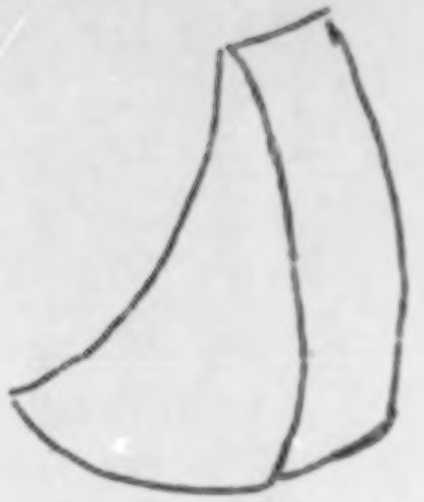
Part C -- Which answer has the two ideas that go together best?

1. heavy ball--fast swing
2. heavy ball--slow swing
3. long string--fast swing
4. long string--slow swing

Part D -- Which answer best explains your choices to Parts A, B, and C?

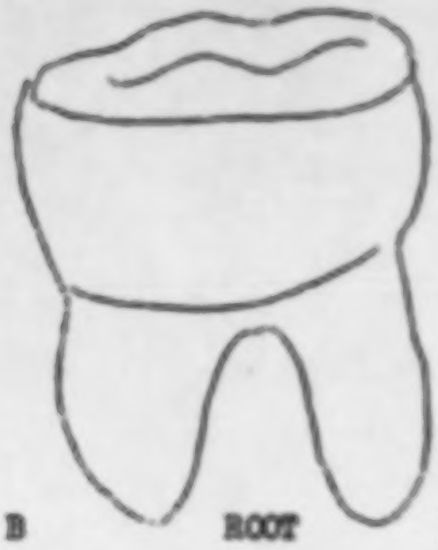
1. As a ball is made heavier, it swings slower.
2. As a ball is made lighter, it swings slower.
3. As the string is shortened, a ball swings faster.
4. As the string is shortened, a ball swings slower.

PROBLEM 5
GRADE FOUR



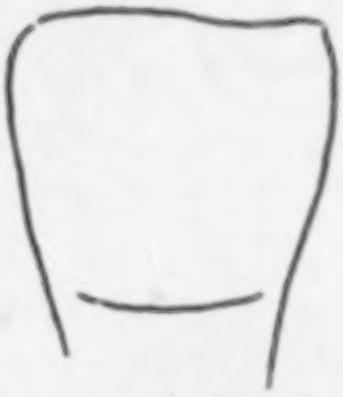
A SHARP AND POINTED

____



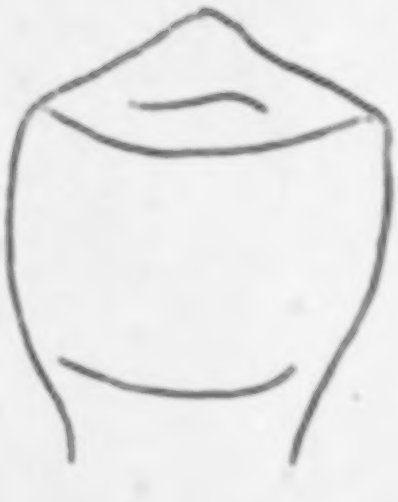
B WIDE AND FLAT

____



C THIN AND NARROW

____



D MEDIUM POINTED AND SHARP

____

THESE ARE PICTURES OF TEETH WHICH ARE FOUND IN MAN AND ANIMALS.

PROBLEM 5
GRADE FOUR

Part A -- If a rabbit had your teeth, what would happen?

1. It would be able to eat only carrots.
2. It could eat only soft foods.
3. It could eat many kinds of food.
4. It could eat only raw food.

Part B -- In order for an animal to be able to eat nuts, it must have teeth that are:

1. like A.
2. like B.
3. like C.
4. like D.
5. like C and D.

Part C -- Which answer has the two ideas that go together best?

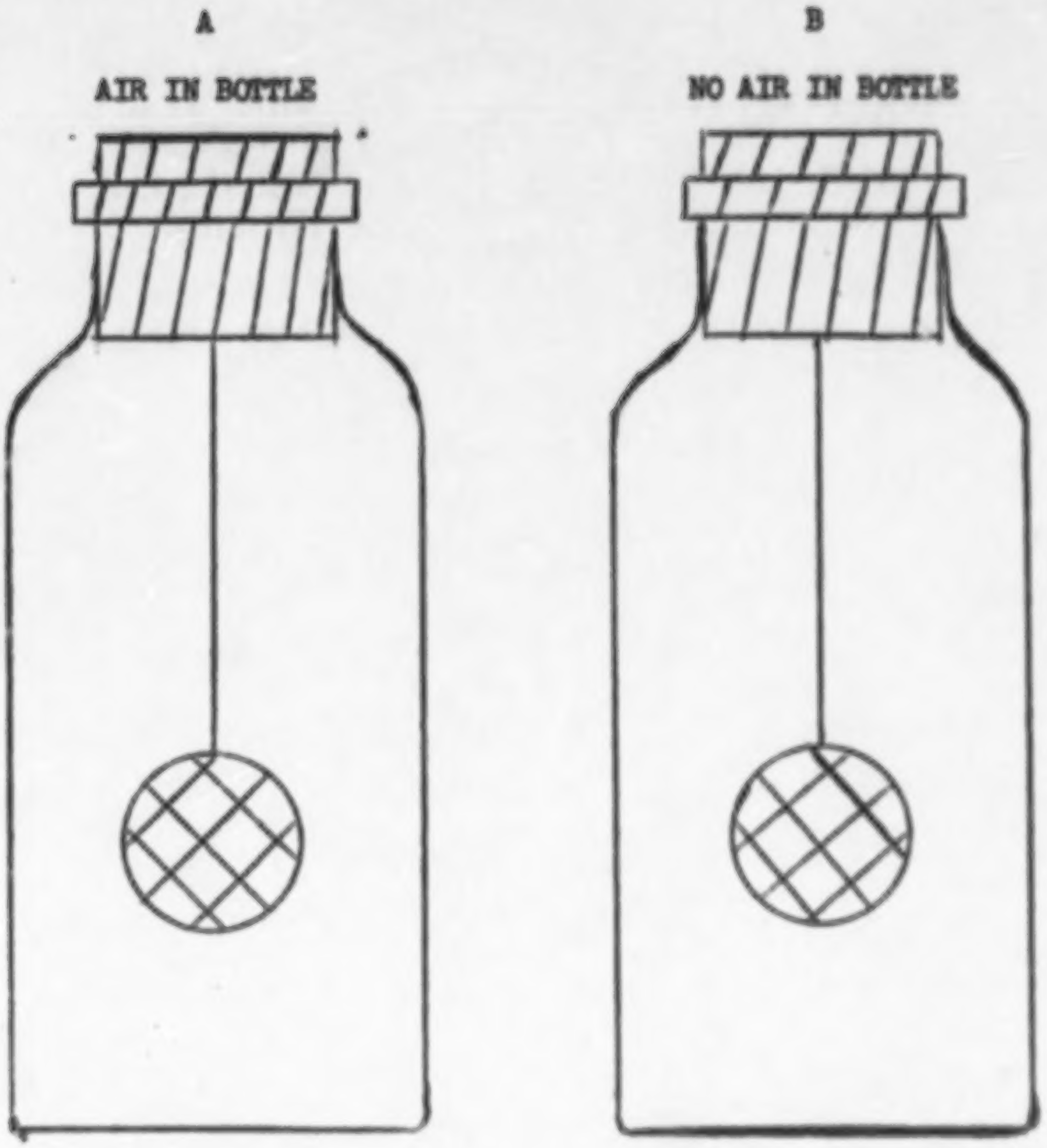
1. pointed, sharp teeth--soft foods
2. pointed, sharp teeth--hard foods
3. wide flat teeth--hard foods
4. wide, flat teeth--meat foods

Part D -- Which answer best explains your choices to Parts A, B, and C?

1. All animals have the same kind of teeth.
2. Different groups of animals have the same kinds of teeth.
3. Different groups of animals have different kinds of teeth.
4. Animals can eat food of any kind.

PROBLEM 3

GRADE FIVE


A
AIR IN BOTTLE
B
NO AIR IN BOTTLE

Two bottles have stoppers in them. A steel ball is hanging from each stopper.

Everything is exactly the same in each bottle, except that there is air in bottle A and no air in Bottle B.

PROBLEM 3
GRADE FIVE

Part A -- If the bottles are moved so that the steel balls start swinging, what will happen?

1. Steel ball A will stop swinging first.
2. Steel ball B will stop swinging first.
3. They will both stop swinging at the same time.
4. They will both swing together at all times.

Part B -- In order for the ball in bottle A to swing for a longer time, what would you do?

1. Put more air in bottle A.
2. Put the ball and string into a larger bottle.
3. Take out the air.
4. Wrap paper around the ball.

Part C -- Which answer has the two ideas which go together best?

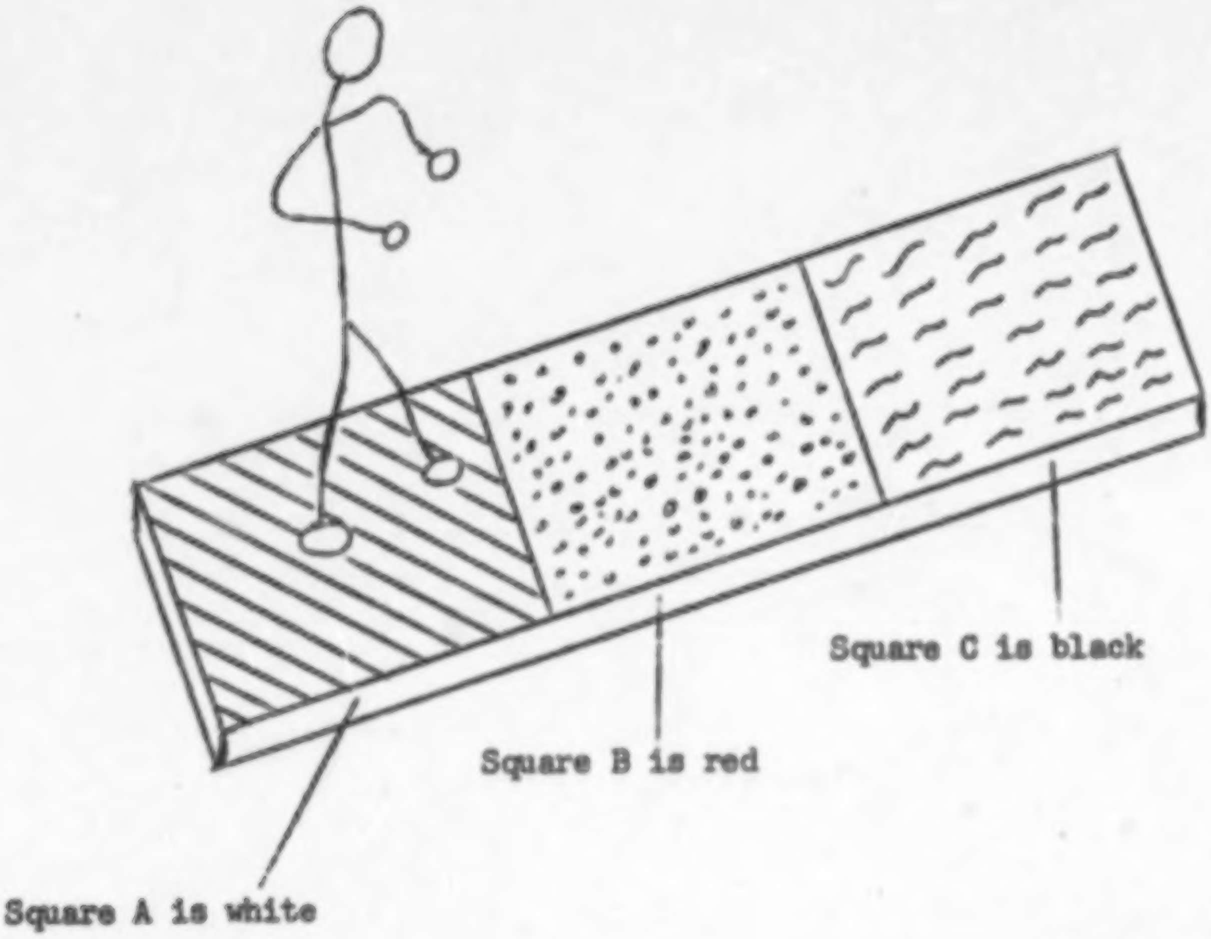
1. no air--ball stops sooner
2. no air--ball swings longer
3. more air--ball swings longer
4. less air--ball stops sooner

Part D -- Which answer best explains your choices to Parts A, B, and C?

1. Balls on strings the same length swing together.
2. Balls on strings the same length always swing differently.
3. Air does not slow down swinging balls.
4. Air does slow down swinging balls.

PROBLEM 2

GRADE SIX


Square C is black
Square B is red
Square A is white

This sidewalk is in full sunlight. Square A has been painted white; Square B has been painted red; Square C has been painted black.

PROBLEM 2

GRADE SIX

Part A -- If the boy walked barefoot across all squares of the sidewalk what would happen?

1. Square A would feel hottest.
2. Square B would feel hottest.
3. Square C would feel hottest.
4. All the squares would feel the same.

____

Part B -- In order to make square B of the sidewalk feel warmer, what could you do?

1. Paint it a darker color.
2. Paint it a warm color.
3. Paint it a lighter color.
4. Leave it as it is.

____

Part C -- Which answer has the two ideas that go together best?

1. darker color--feels warmer
2. lighter color--feels warmer
3. darker color--feels cooler
4. darker color--feels the same

____

Part D -- Which answer best explains your choices to Parts A, B, and C?

1. The lighter the color, the more heat remains in the sidewalk.
2. The darker the color, the more heat remains in the sidewalk.
3. Color makes no difference in the amount of heat in a sidewalk.
4. The darker the color, the less heat remains in the sidewalk.

____

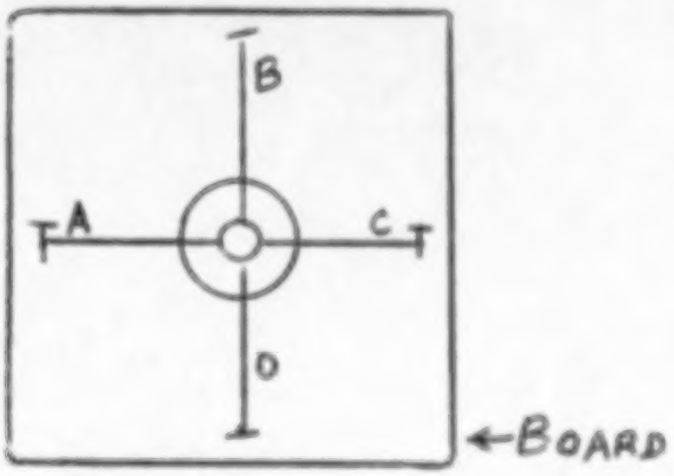
APPENDIX B

Sample Science Lessons for each Grade

INQUIRY PROBLEM SHEET - BALANCE OF FORCES

Grade 4

A washer is held in position with four rubber bands.



Problem:

Why does the weight move when rubber band A is cut? Why does the weight stop moving after the rubber band is cut?

Episode Analysis:

When the rubber band is cut, the forces become unbalanced and the weight moves. When the forces become balanced again, the weight stops moving.

Variables:

1. size of weight
2. shape of weight
3. position of weight
4. size of rubber bands
5. number of rubber bands
6. position of rubber bands
7. replace rubber bands with other materials

Critical Questions:

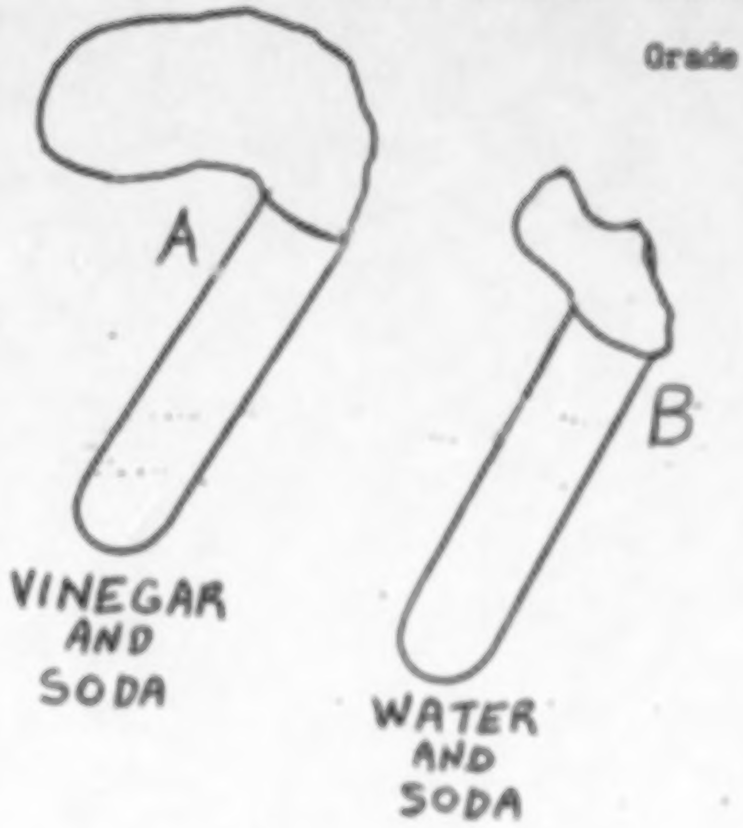
1. In order for an object to move, what must happen to the forces acting on it?
2. Would the same thing happen in a vacuum? Why?
3. Would the same thing happen if there were no gravity? Why not?
4. Would the results be the same if we replace the rubber bands with strings? Why?
5. In order for an object to stand still, what must happen to the forces acting on it?

Cause-effect relationships:

1. When an object is moving, the forces acting on it are not balanced.
2. When an object is not moving, the forces acting on it are balanced.
3. Transfer of energy: the energy is transferred from the rubber band that is cut to the remaining rubber bands.

LABORATORY GUIDE--PHYSICAL CHEMICAL CHANGE

Grade 5



Materials:

1. white vinegar or dilute acetic acid
2. water
3. soda
4. test tubes
5. balloons

Two test tubes containing equal amounts of clear liquid are placed on the table. Equal amounts of soda are placed in each, then a balloon is put on each one.

Problem: Why did balloon A expand and not balloon B?

Variables:

1. heat both test tubes
2. change amounts of chemical
3. change amounts of liquid
4. cool both test tubes
5. stopper both test tubes

Critical questions:

1. In order to have balloons A and B act the same, what could you do?

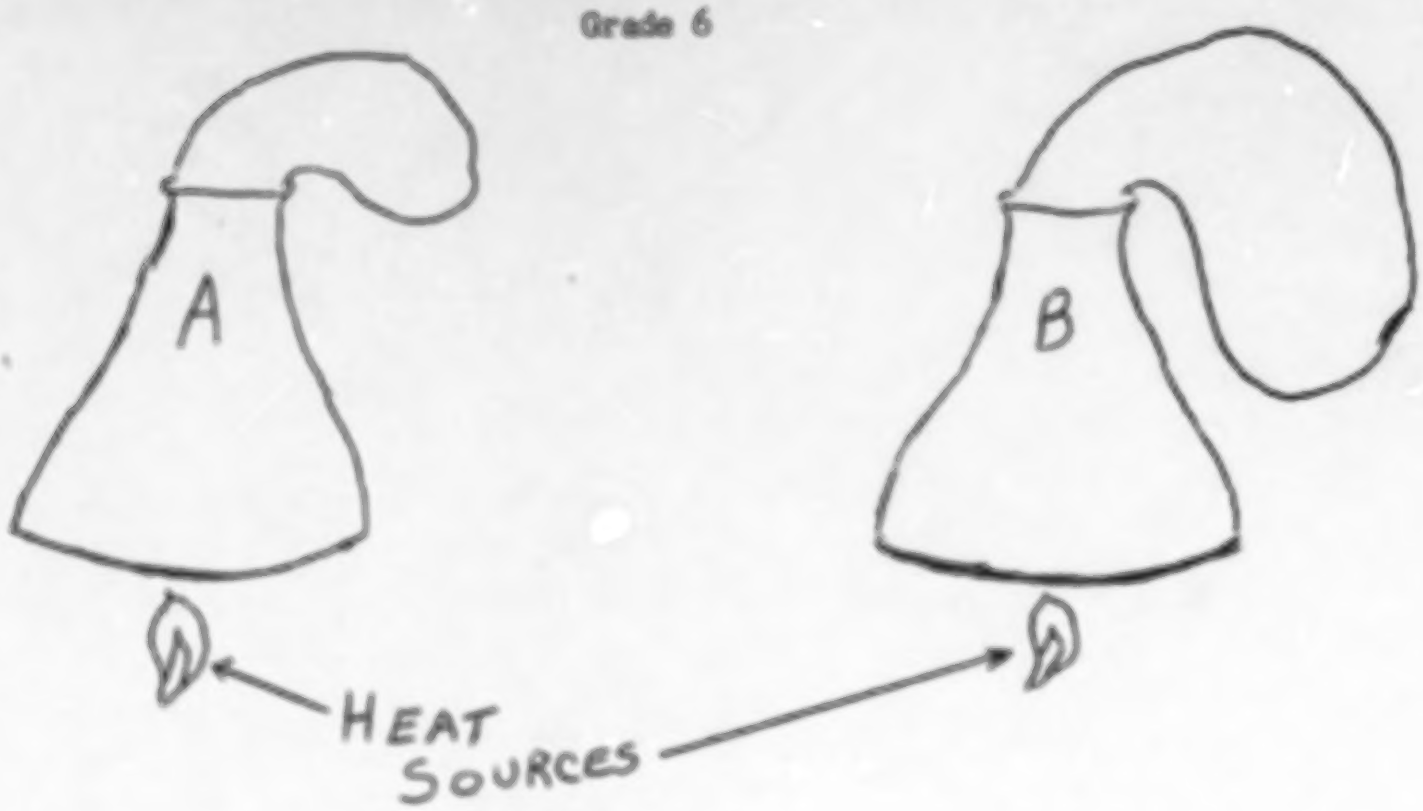
2. If both flasks are cooled to room temperature, what would you find in either flask?

3. If all the water is allowed to evaporate from B, what would be left?

4. If all the vinegar is allowed to evaporate from A, what would be left?

INQUIRY SESSION SHEET--EXPANSION IN CHANGE OF STATE (GASES)

Grade 6



A and B are two flasks topped by balloons. They are identical except one flask contains a teaspoon of water.

Problem: Why did balloon B get so much larger than A when both were heated?

Episode Analysis:

When flasks A and B are heated equally, flask A begins to expand sooner than flask B. The air alone does not require much heat to expand it. Suddenly balloon B mushrooms, becoming much larger than A. This occurs because the water, in changing to a gas, expands many times, exerting more pressure or force on balloon B than balloon A.

Variables:

1. size of balloon
2. heat source
3. kind of container
4. kind of liquid (keep quantity small)

Critical Questions:

1. If we tied a string at the neck of B and took it off to play, what would happen?
2. How could you make balloon A expand twice as much as balloon B?
3. Why does popcorn pop?

APPENDIX C

SCST Task Instructions

Cards 1, 2, 19, and 20 of the SCST

3

CST INSTRUCTIONS

Before testing, place this on the blackboard:

1		
2		

Then, pass out the answer pads and instruct the pupils to fill in, on the front page, the following:

1. Complete name
2. Section
3. Grade
4. Sex

Also, have them write the school name at the very top.

When the pupils are finished, wait for them to lay down their pencils. Hold up the Style Booklet and say:

Do not open or turn these until I tell you to do so.

Pass out the Style Booklets, then say:

Turn over the top card now. Here is a set of cards on which are pictures of many familiar things. On Card number 1 you can see three pictures: the tomato has an A under it; the pear a B underneath; and the apple a C beneath it. What I want you to do is to pick out any *two* of the three pictures which *go together*, *belong together*, or *are related in any way*, then you would write the letters A and C on the *middle left hand* square like this:

Go to the blackboard and write the two letters in the appropriate box. Then say:

Notice that I wrote the letters in the box next to the card number. Look at your answer pads. You do not have a box for Card number 1. That is because we will all work this card together as a sample on the blackboard. Next to the letters A and C you can write the reason, or reasons, why A and C were picked.

Elicit choices from the pupils and write these on the board. Then say:

You could also pick out other pairs; for example, B and C.

Write B and C on the board and elicit responses from the pupils. Say:

It is possible to pick a third pair; for instance, A and B.

Elicit responses again and place them on the board. Then say:

When I ask you to go ahead, I want you to put down as many pairs for a card as you wish, that go together, belong together, or are related in any way, and give your reason, or reasons, for each choice. Continue giving as many pairs, and your reasons, as you wish for a card, then go on to the next card. Continue with the cards until you get to the last card. Then close your booklet, bring your answer pad to me, and I will give you an illustrated booklet to read until the rest of the class finishes.

Pause. Then say:

Here is some very important information: This task has nothing to do with your school marks. There are no right or wrong answers. We are interested in the different ways that children see things. Some of you may see many things; some of you only a few. Don't worry about this; just do it as well as you can. Don't worry about spelling or neatness. If you wish to change your reason, simply cross out, or erase, the old reason and write in the new. Always keep the reason, or reasons, right across from the two letters that you choose so that I will know what reason goes with what letters. Check to see that your letter combinations and reasons are written in the squares next to the box with the same number as the card on which you are working. Are there any questions?

Answer the questions. There should be only a few. Then say:

Everybody turn to Card 2 and begin. Take your time.

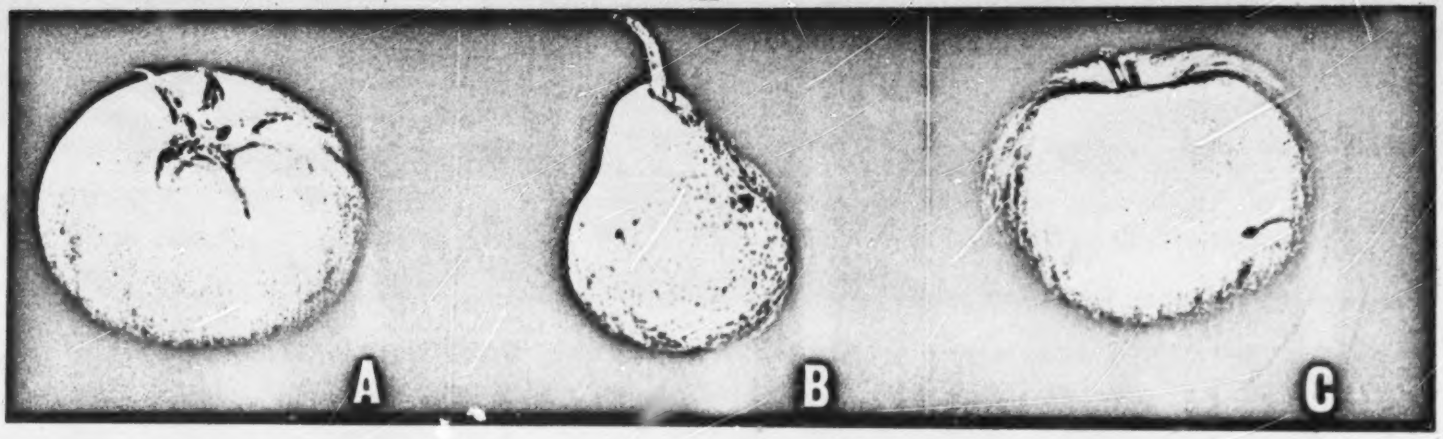
Circulate for the first 5-10 minutes, looking for the following:

1. Children using a three letter combination instead of two. Have them erase one letter of their choice.
2. Children skipping squares, or card numbers. Have them go back and fill in, or otherwise make the right adjustments.
3. Some children--a very few--might skip some pictures entirely, and deliberately. Encourage them to give one reason for each page if at all possible. We are interested in how they see things.

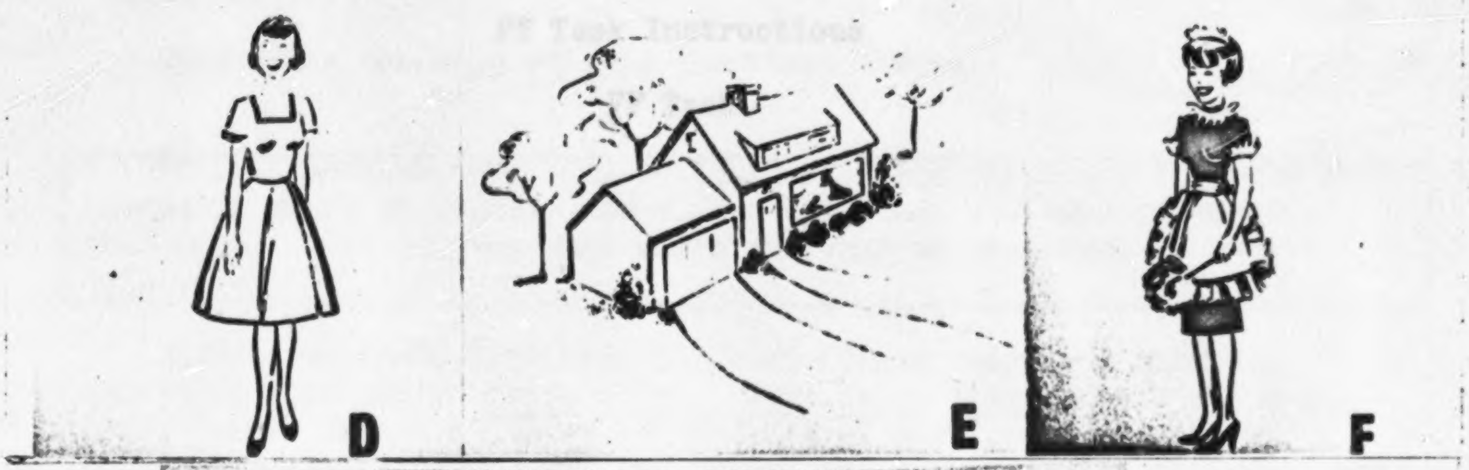
When each child finishes, give his answer pad a quick check for completness--name, school, grade, section, completed squares, etc.

SCST Cards 1, 2, 19, and 20

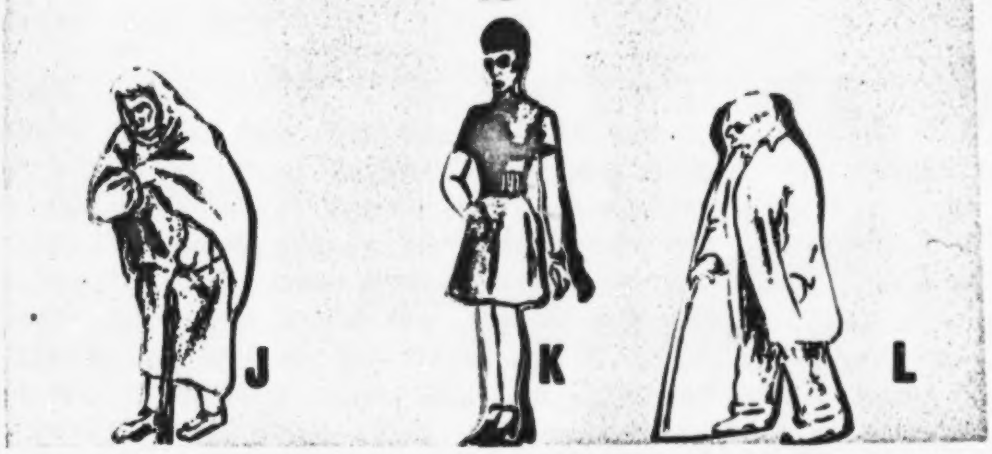
1



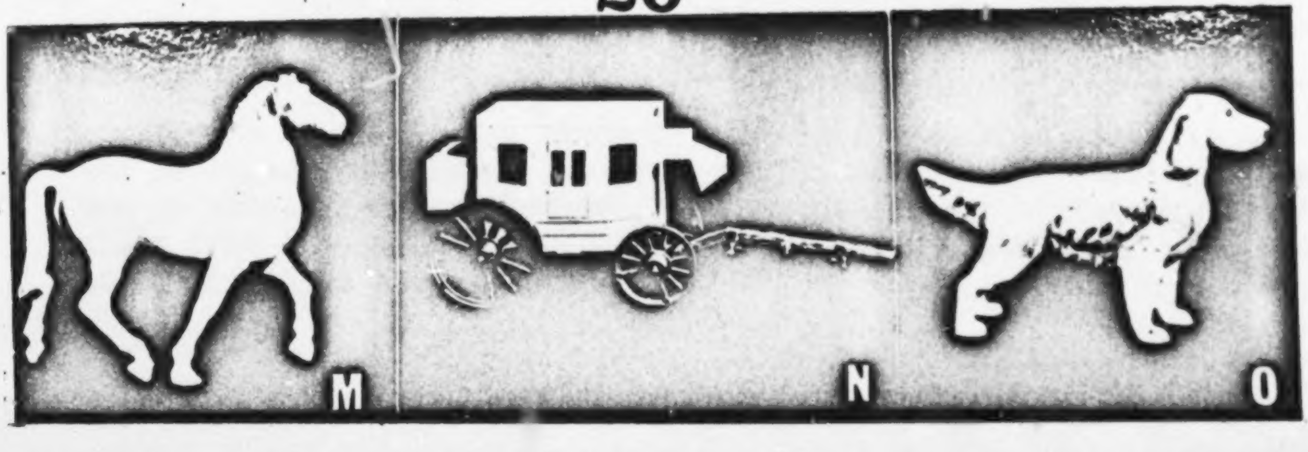
2



19



20



APPENDIX D

FF Task Instructions

FF Task

CREATIVITY TASK INSTRUCTIONS

Pass out the task sheets and instruct the pupils to fill in the blanks on both pages. Write the word newspaper on the blackboard and say:

> We are interested in the different ideas children have about things. For instance, a newspaper is to read, but you can also do many other, different things with it. Lets see how many different ways we can list under this word on the board.

Elicit responses from the children. Their responses might be very fine, but they may also be redundant. For example: spread on the floor and lay on a table. Point out to the children that these kinds of examples are really duplications since both instances involve covering an object. Emphasize that we are interested in different categories of uses.

Then write the word fair on the board and say:

> Here is another word--fair. It is a little different from the word newspaper since it usually means something that you cannot see with your eyes. Lets see how many different ways we can think of to use this word.

Elicit responses from the children. Their responses should go something like this: fair, like a mark; fair, like a day; fair skin; State Fair. Again, if there is evidence of duplication, call the children's attention to this and stress the importance of different ways.

After this say:

> What I want you to do now is to list as many different ways as you can think of for the four words that are on your task sheets. There are no right or wrong answers. We are merely interested in how many ideas children have. Don't worry about spelling--just do the best you can. On the first sheet, the two words are screwdriver and brick. These are like the word newspaper since you can see these objects. On the next page, the words are honest and good. These are like the word fair since you cannot see these words anywhere except in a word. Some of you may have many ideas for one word and not so many for another. Don't worry about this--just do the best you can. If you need more space than we have provided, just use the back of your page. You may have the rest of the period to work on this task. Some of you may finish earlier than others. As soon as you finish, you may read the books that I have provided. Ready? Begin.

During the first few minutes, circulate around in order to see that the children are working satisfactorily. Most pupils should finish in one 40 minute period. However, if extenuating circumstances prevent a child from finishing in one period, there is nothing wrong with letting him finish at a later date.

D-2

NAME________________________ SCHOOL____________________

SECTION____ GRADE____ SEX____ BIRTHDAY____________________

BRICK	SCREWDRIVER
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.
7.	7.
8.	8.
9.	9.
10.	10.
11.	11.
12.	12.
13.	13.
14.	14.
15.	15.
16.	16.
17.	17.
18.	18.
19.	19.
20.	20.
21.	21.
22.	22.

D-3

NAME______________________________ SCHOOL______________________________

HONEST

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.

GOOD

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.